AD-A033 538 HONEYWELL INC ST PETERSBURG FLA AEROSPACE DIV F/G 17/2
ATEC DIGITAL ADAPTATION STUDY. VOLUME I. FKV REQUIREMENTS FOR P--ETC(U)
OCT 76 T R ARMSTRONG, A K BLOUGH F30602-75-C-0282
UNCLASSIFIED 476-13656-VOL-1 RADC-TR-76-302-VOL-1 NL

1 OF 5
ADA033538

F.G.

12

RADC-TR-76-302, Volume I (of three)
Final Technical Report
October 1976

ATEC DIGITAL ADAPTATION STUDY
FKV Requirements for PA/FI/TA

Honeywell Inc

Approved for public release;
distribution unlimited.

ROME AIR DEVELOPMENT CENTER
AIR FORCE SYSTEMS COMMAND
GRIFFISS AIR FORCE BASE, NEW YORK 13441

This report has been reviewed by the RADC Information Office (OI) and is releasable to the National Technical Information Service (NTIS). At NTIS it will be releasable to the general public, including foreign nations.

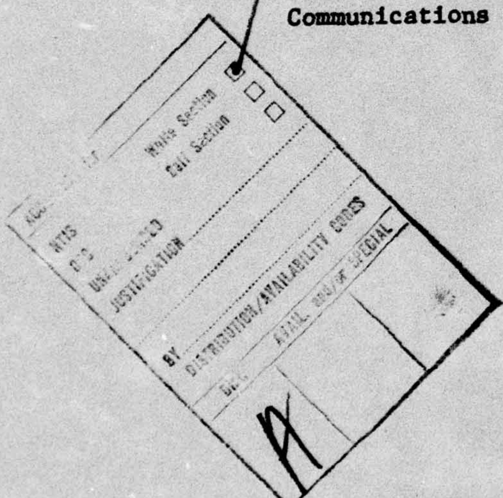
This report has been reviewed and approved for publication.

APPROVED:

ARNOLD E. ARGENZIA
Project Engineer

APPROVED:

FRED I. DIAMOND
Technical Director
Communications & Control Division



FOR THE COMMANDER:

JOHN P. HUSS
Acting Chief, Plans Office

Do not return this copy. Retain or destroy.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: (18) RADC (19) TR-76-302-Vol-I (of three)	2. GOVT ACCESSION NO.
	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle): (6) ATEC DIGITAL ADAPTATION STUDY. Volume I. FKV Requirements for PA/FI/TA.	5. TYPE OF REPORT & PERIOD COVERED: (9) Final Technical Report. 27 Jun 75 - 29 Feb 76.
	6. PERFORMING ORG. REPORT NUMBER: (14) 476-13656 - Vol-I
7. AUTHOR(s): (10) T. R. Armstrong, D. T. Doyle, Mr. A. K. Blough Jr., Mr. E. N. Dulaney, Mr. T. J. Campbell, Mr. R. A. Ziesmer	8. CONTRACT OR GRANT NUMBER(s): (15) F30602-75-C-0282 NEW
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Honeywell Inc./Aerospace Division, 13350 U. S. Highway 19, St. Petersburg FL 33733	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 33126F, 21550101 PE3
11. CONTROLLING OFFICE NAME AND ADDRESS: Rome Air Development Center (DCLD), Griffiss AFB NY 13441	12. REPORT DATE: (11) October 1976
	13. NUMBER OF PAGES: 381 (12) 405p.
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office): Same	15. SECURITY CLASS. (of this report): UNCLASSIFIED
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE: N/A

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

A033 566

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

Same

18. SUPPLEMENTARY NOTES

RADC Project Engineer:
Arnold E. Argenzia (DCLD)

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Performance Assessment, Fault Isolation, and Trend Analysis (PA/FI/TA) in Digital Transmission Systems.
ATEC (Automated Technical Control) Applicability for PA/FI/TA in the FKV Digital Transmission System.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The ATEC Digital Adaptation Study sought to answer the questions: (1) What should be monitored for PA/FI/TA of the FKV system; (2) What measurements, data collection, and analysis should a monitor system perform, (3) Is the ATEC system and equipments applicable in satisfying the measurement and analysis requirements, either unmodified or with minor adaptations, and (4) Can an ATEC/FKV demonstration be performed: The study addressed each of these questions, in turn, and the answer is that the ATEC system and equipments, augmented by minor hardware and software adaptations, can satisfy all the

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED 403 190.

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

bpg

PA/FI/TA monitoring system requirements for the FKV digital transmission system. An ATEC monitoring system for the entire FKV system is presented and operational characteristics dealing with all aspects of the monitoring system are presented. In addition, an ATEC/FKV demonstration configuration is presented which would enable the validation of the ATEC digital transmission system monitoring capability through field testing and data collection on a link within the FKV system.

SUMMARY

The Frankfurt-Koenigstuhl-Vaihingen (FKV) digital transmission system and its equipments were studied and analyzed for the purpose of identifying points of attachment which can be used to gather system and equipment operational and status information contributing to Performance Assessment, Fault Isolation, and Trend Analysis (PA/FI/TA) of the FKV system. This study encompassed research of Digital Transmission Theory coupled with specific study and analysis of the FKV system and equipments. Initial study was performed completely independent of a monitoring system approach. The result was a set of digital transmission performance objectives addressing availability, BER, error free seconds, BCI, jitter, PCM noise, and performance margin plus a comprehensive candidate monitor point list identifying those system and equipment monitor points judged as contributing to performance assessment, fault isolation or trend analysis.

The initial list was reduced using the system engineering tool of a selection matrix evaluation wherein ratings based on engineering judgment and experience were assigned for each candidate monitor point in the categories of usefulness for PA/FI/TA, availability of the monitor point for signal extraction, and the amount of hardware or software processing needed to use the collected information. The sum of the weighted ratings resulted in a GOODNESS value for PA/TA and FI for each candidate monitor point. The GOODNESS value was compared against a predetermined cutoff value resulting in a preliminary monitor point list, independent of a monitoring system approach.

Following the generation of a preliminary monitor point list, a monitoring system approach, independent of ATEC, was formulated for the FKV system based on monitoring system considerations for PA/FI/TA, reaction time, scan time, scan sequences, and telemetry utilization. An evaluation of the preliminary monitor point list against the requirements of the proposed monitoring system resulted in a recommended monitor point list for the FKV system.

A computer simulation was used to study the effects of cascading equipment alarms as a result of equipment degradation or failure. The results illustrated the alarm cascading problem and ultimately led to the establishment of a sudden service failure sensing system which provides rapid notice of system service failure, but otherwise does not burden the tech control operator with cascading alarms.

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (CONTINUED)

LIST OF ILLUSTRATIONS (CONTINUED)

LIST OF TABLES

LIST OF TABLES (CONTINUED)

EVALUATION

The evolution of the Defense Communications System (DCS) from an analog system through a hybrid (analog/digital) configuration to an all-digital posture is a transitional process that is expected to span the next two decades. The Frankfurt-Koenigstuhl-Vaihingen (FKV) segment of the European DCS is an example of such a transition. ATEC is a current effort to provide the benefits of automation to today's primarily manual tech control facilities in the DCS.

The ATEC Digital Adaptation Study served to:

a. identify the FKV digital transmission performance objectives

b. identify the Communications Performance Monitoring Assessemt System (CPMAS) requirements of the FKV.

c. identify the parameters/alarms that would in fact satisfy these CPMAS requirements.

d. determine ATEC's applicability in satisfying the specified CPMAS requirements.

e. identify the adaptations to ATEC that are required in order to demonstrate its feasibility on a FKV type system.

The feasibility of the proposed ATEC digital communications performance monitoring assessment capability will be demonstrated via a DT&E effort at Ft. Huachuca AZ.

The combined results of the study and DT&E will serve as inputs to the ATEC full scale production program.

Arnold E. Argenzia

ARNOLD E. ARGENZIA
Project Engineer

Section 1

INTRODUCTION

1.1 SCOPE OF ATEC DIGITAL ADAPTATION STUDY

Worldwide communications throughout the Defense Communication System (DCS) is currently provided over predominately analog transmission systems using frequency division multiplex (FDM) techniques to combine user circuits prior to transmission over the communications network. Future DCS upgrades are scheduled to replace existing FDM equipments with pulse code modulation (PCM) and time division multiplex (TDM) equipments at selected terminals. Such upgrades will result in predominately digital rather than analog signals in the technical control area.

The ATEC (Automated Tech Control) program has developed a system and family of equipments which provide automated tech control of FDM analog systems in the area of performance assessment, fault isolation, and trend analysis. The DCS evolution to digital systems as typified by the FKV (Frankfurt-Koenigstuhl-Vaihingen) system upgrade to PCM/TDM has raised the question as to the applicability of the ATEC system to perform the functions of performance assessment, fault isolation, and trend analysis in a digital transmission system.

1.2 PROGRAM OBJECTIVES

Study objectives were: (1) identify what system and equipment monitor point information should be collected to perform performance assessment, fault isolation and trend analysis for the FKV system, (2) determine the requirements for a monitoring system to be used in the FKV system, (3) determine if ATEC can be used either unmodified or with minor adaptations to satisfy the measurement and monitoring requirements, and (4) recommend engineering change proposals which would enable ATEC to be field tested in the FKV system in conjunction with the ATEC JOT&E.

Volume I of this report addresses the FKV system monitoring requirements as determined during a study and analysis of system level considerations and requirements augmented by a detailed equipment analysis to identify what monitor points should be collected to perform performance assessment, fault isolation, and trend analysis for the FKV system.

Section 2

FKV SYSTEM PERFORMANCE MONITORING

2.1 The FKV SYSTEM

2.1.1 FKV System Description

2.1.1.1 FKV Communications Equipment

This subsection advances a brief discussion of the physical configuration and network operation of the FKV System.

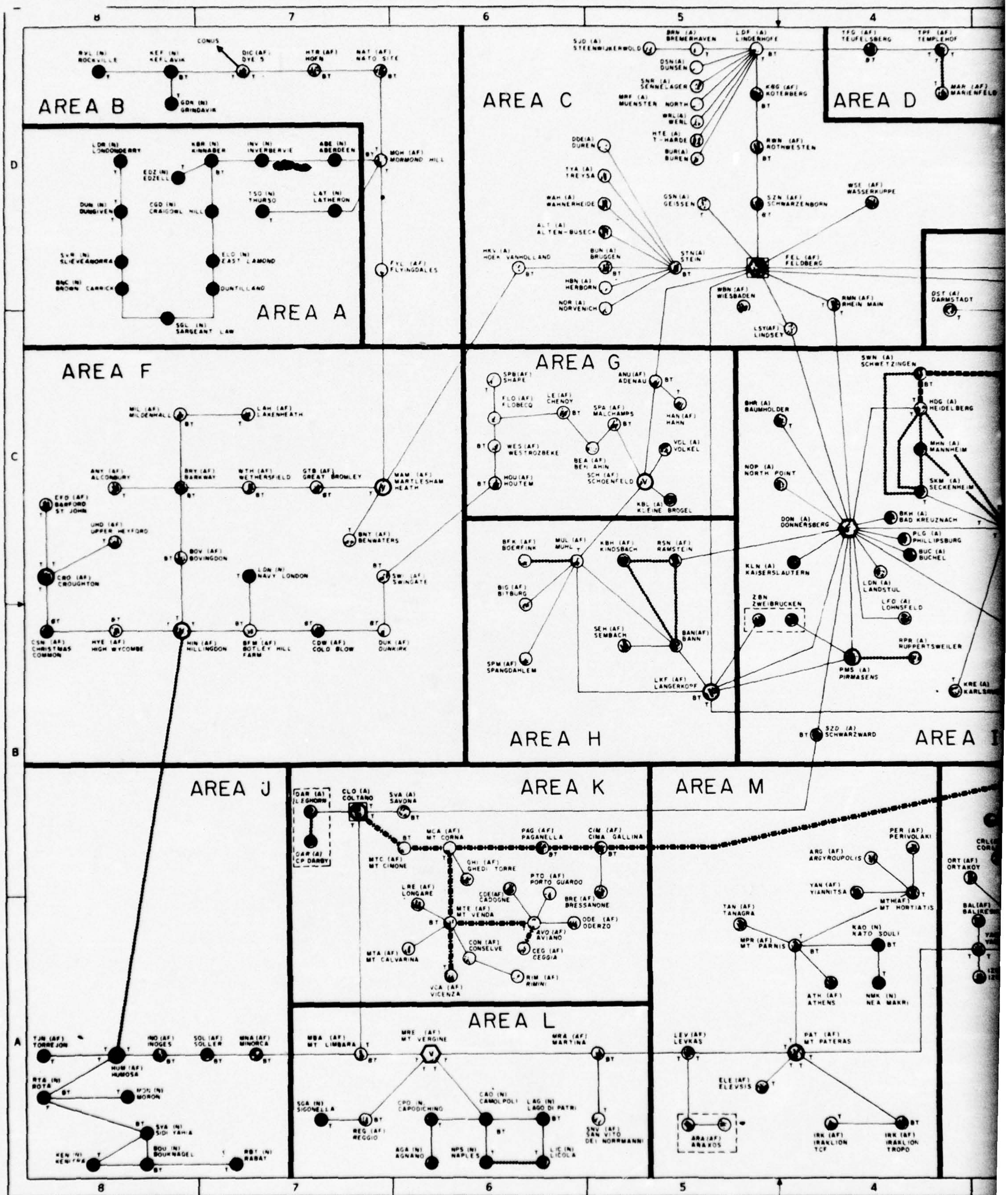
The FKV system is a digital communication network which constitutes an upgrade of, and hence is an integral part of, the European Defense Communication System. Figure 2-1 illustrates the relation between the DCS and the FKV. It may be observed that the FKV encompasses links from Vaihingen through Stuttgart, Stocksburg, Koenigstuhl, Swetzingen to Heidelberg.

Equipment configuration with respect to physical location is diagrammed in Figure 2-2. Complete equipment descriptions are presented in Paragraphs 3.1 through 3.5; however, a consensed description is given here for ready reference.

A CY-104 is composed of a PCM voice digitizer, a TDM which combines or separates 24 digitized voice channels and a KG-34 which encrypts or decrypts the resultant 1.544 Mb/s digital data stream. The CY-104 provides the interface between 24 analog VF users and a digital 1.544 Mb/s data stream.

A low-speed digital interface to the FKV system is provided by the TlWBl multiplexers. The TlWBl is an asynchronous TDM which accepts eight input channels, where each channel may have a data rate as high as 50 Kb/s. As is the case with the CY-104, the output data rate of the TlWBl into the FKV system is 1.544 Mb/s.

The high-level multiplexer employed in the FKV is the Tl-4000. This unit, as configured for FKV use, accepts eight 1.544 Mb/s data streams and combines them into a 12.6 Mb/s stream. Due to the use of bit stuffing techniques, the input data rates need not be frequency locked. To conserve bandwidth, the Tl-4000 output data stream, 12.6 Mb/s, is encoded in duobinary or Class I partial response format. When compared to binary transmission, this format has the disadvantage of requiring a higher signal-to-noise ratio, but has the advantage of an effectively reduced bandwidth with zero signal energy at the band edges.



AREA A
AREA B
AREA C
AREA D
AREA F
AREA G
AREA H
AREA J
AREA K
AREA L
AREA M
CONUS
RVL (N) ROCKVILLE
KEF (N) KEFLAVIK
GDN (N) GRINDAVIK
DIC (AF) DYE 5
HTR (AF) HOFN
NAT (AF) NATO SITE
LDR (N) LONDONDERRY
KBR (N) KINNABER
INV (N) INVERBERVIE
ABE (N) ABERDEEN
MOH (AF) MORMOND HILL
EDZ (N) EDZELL
DUN (N) DUNGIVEN
CGD (N) CRAIGOWL HILL
TSO (N) THURSO
LAT (N) LATHERON
SVR (N) SLIEVEANORRA
ELO (N) EAST LAMOND
BNC (N) BROWN CARRICK
DUNTILLAND
SGL (N) SARGEANT LAW
FYL (AF) FLYINGDALES
SJD (A) STEENWIJKERWOLD
BRN (A) BREMERHAVEN
LDF (A) LINDERHOFE
DSN (A) DUNSEN
SNR (A) SENNELAGER
MRF (A) MUENSTER NORTH
WRL (A) WERL
HTE (A) T-HARDE
BUR (A) BUREN
KBG (AF) KOTERBERG
RWN (AF) ROTHWESTEN
SZN (AF) SCHWARZENBORN
WSE (AF) WASSERKUPPE
TFG (AF) TEUFELSBERG
TPF (AF) TEMPLEHOF
MAR (AF) MARIENFELD
DDE (A) DUREN
TYA (A) TREYSA
WAH (A) WAHNERHEIDE
GSN (A) GEISSEN
ALT (A) ALTEN-BUSECK
HKV (A) HOEK VANHOLLAND
BGN (A) BRUGGEN
STN (A) STEIN
FEL (AF) FELDBERG
HBN (A) HERBORN
NOR (A) NORVENICH
WBN (AF) WIESBADEN
RMN (AF) RHEIN MAIN
DST (A) DARMSTADT
LSY (AF) LINDSEY
MIL (AF) MILDENHALL
LAH (AF) LAKENHEATH
ANY (AF) ALCONBURY
BRY (AF) BARKWAY
WTH (AF) WETHERSFIELD
GTB (AF) GREAT BROMLEY
MAM (AF) MARTLESHAM HEATH
CFD (AF) BARFORD ST JOHN
UHD (AF) UPPER HEYFORD
BNT (AF) BENWATERS
BOV (AF) BOVINGDON
CRO (AF) CROUGHTON
LDN (N) NAVY LONDON
SWI (AF) SWINGATE
CSN (AF) CHRISTMAS COMMON
HYE (AF) HIGH WYCOMBE
HIN (AF) HILLINGDON
BFM (AF) BOTLEY HILL FARM
CDW (AF) COLD BLOW
DUK (AF) DUNKIRK
SPB (AF) SHAPE
FLO (AF) FLOBECQ
LE (AF) CHENOY
ANU (AF) ADENAU
HAN (AF) HAHN
SPA (AF) MALCHAMPS
WES (AF) WESTROZBEKE
VOL (A) VOLKEL
BEA (AF) BEN AHIN
SCH (AF) SCHOENFELD
HOU (AF) HOUTEM
KBL (A) KLEINE BROGEL
SWN (A) SCHWETZINGEN
HDG (A) HEIDELBERG
BHR (A) BAUMHOLDER
MHN (A) MANNHEIM
NOP (A) NORTH POINT
SKM (A) SECKENHEIM
DON (A) DONNERSBERG
BKH (A) BAD KREUZNACH
PLG (A) PHILLIPSBURG
BUC (A) BUCHEL
BFK (AF) BOERFINK
MUL (AF) MUHL
KBH (AF) KINDSBACH
RSN (AF) RAMSTEIN
KLN (A) KAISERSLAUTERN
LDN (A) LANDSTUL
BIG (AF) BITBURG
LFD (A) LOHNSFELD
ZBN ZWEIBRUCKEN
SEH (AF) SEMBACH
BAN (AF) BANN
RPR (A) RUPPERTSWEILER
PMS (A) PIRMASENS
SPM (AF) SPANGDAHLEM
LKF (AF) LANGERKOPF
KRE (A) KARLSRUHE
SZD (A) SCHWARZWARD
DAR (A) LEGHORN
CLO (A) COLTANO
SVA (A) SAVONA
MCA (AF) MT CORNA
PAG (AF) PAGANELLA
CIM (AF) CIMA GALLINA
DAR (A) CP DARBY
MTC (AF) MT CIMONE
GHI (AF) GHEDI TORRE
PTO (AF) PORTO GUARDO
LRE (AF) LONGARE
COE (AF) CADOGNE
BRE (AF) BRESSANONE
MTE (AF) MT VENDA
AVO (AF) AVIANO
ODE (AF) ODERZO
CON (AF) CONSELVE
CEG (AF) CEGGIA
MTA (AF) MT CALVARINA
RIM (AF) RIMINI
VCA (AF) VICENZA
PER (AF) PERIVOLAKI
ARG (AF) ARGYROUPOLIS
YAN (AF) YIANNITSA
MTH (AF) MT HORTIATIS
TAN (AF) TANAGRA
MPR (AF) MT PARNIS
KAO (N) KATO SOULI
ATH (AF) ATHENS
NMK (N) NEA MAKRI
ORT (AF) ORTAKOY
TJN (AF) TORREJON
HUM (AF) HUMOSA
INO (AF) INOGES
SOL (AF) SOLLER
MNA (AF) MINORCA
MBA (AF) MT LIMBARA
MRE (AF) MT VERGINE
MRA (AF) MARTINA
LEV (AF) LEVKAS
PAT (AF) MT PATERAS
RTA (N) ROTA
MON (N) MORON
ELE (AF) ELEVSIS
SGA (N) SIGONELLA
REG (AF) REGGIO
CPD (N) CAPODICHINO
CAO (N) CAMOLPOLI
LAG (N) LAGO DI PATRI
SNV (AF) SAN VITO DEI NORMANNI
SVA (N) SIDI YAHIA
ARA (AF) ARAXOS
IRK (AF) IRAKLION TCF
IRK (AF) IRAKLION TROPO
BOU (N) BOUKNAGEL
KEN (N) KENITRA
RBT (N) RABAT
AGA (N) AGNANO
NPS (N) NAPLES
LIC (N) LICOLA
8
7
6
5
4
D
C
B
A

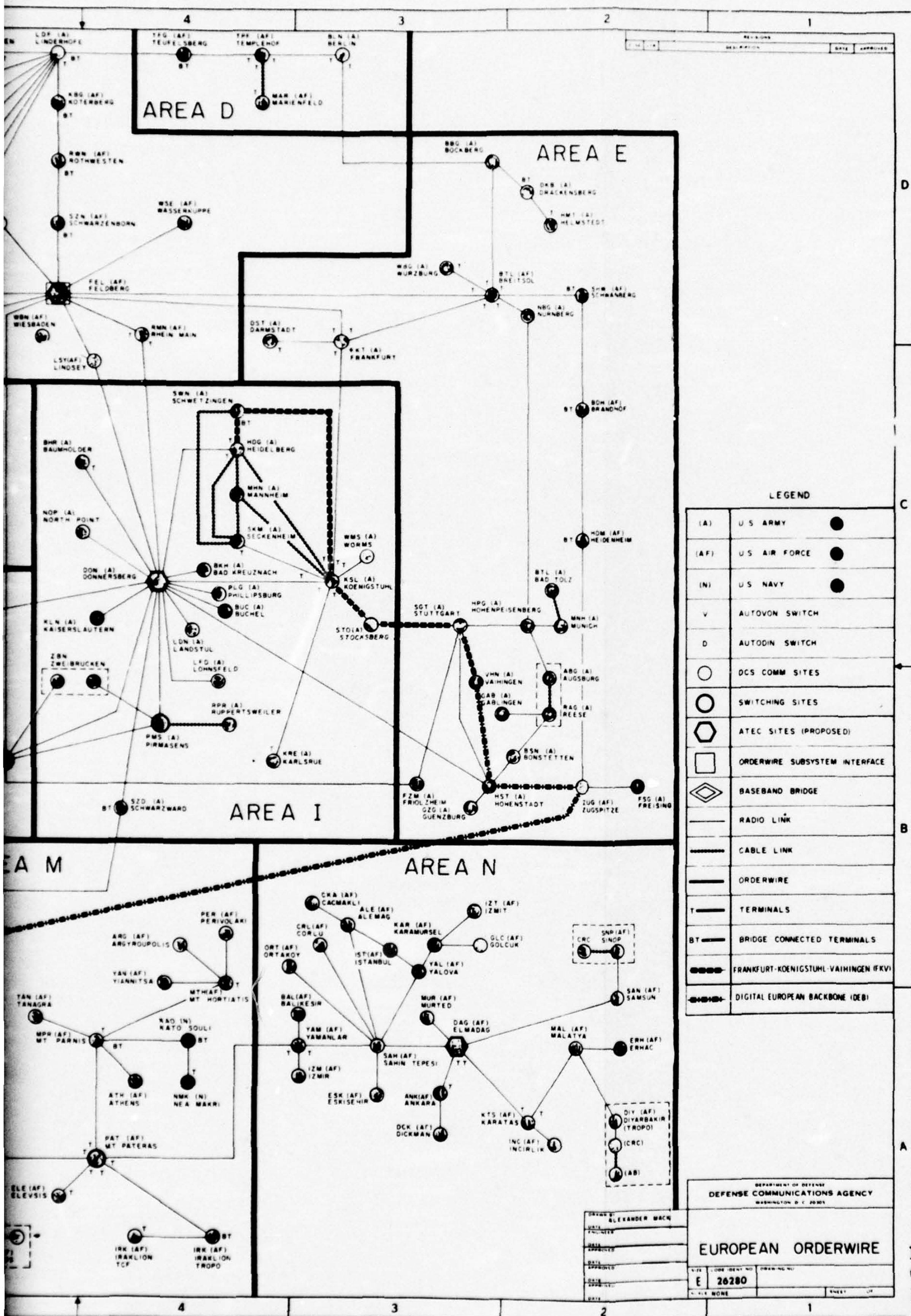


FIGURE 2-1. SYSTEM ORDERWIRE FOR EUROPEAN DCS

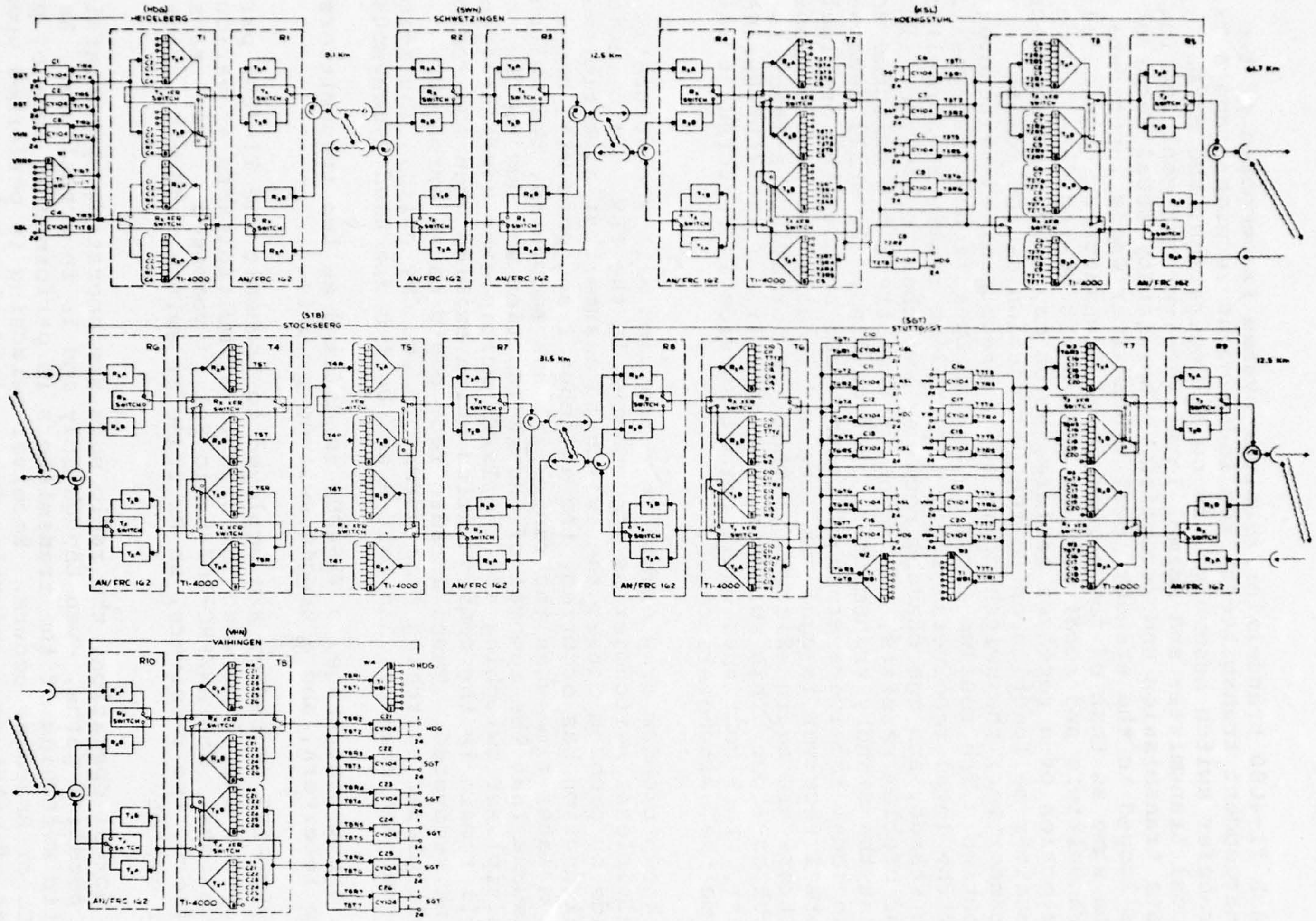


FIGURE 2-2. FKV SYSTEM DIAGRAM

Each T1-4000 transmitter/receiver system is composed of two independent transmitters, two independent receivers and a Tx/Rx transfer switch assembly. In normal operation, the normal local transmitter and normal local receiver are employed for data transmission and reception. The standby local receiver is looped to the standby local transmitter whose input data is the same as that of the normal local transmitter. Hence, all transmitters and receivers are always processing data. Upon detection of a receiver failure, which may be due to an actual receiver malfunction or to the malfunction of the remote transmitter, the switch commences a predetermined switchover routine. The routine first causes an operational transposition of the local receivers; i.e., the on-line receiver (normal) goes to standby and the standby receiver switches to on-line. If the problem persists, the remote transmitters are switched so that the standby transmitter comes on-line. If still necessary, the local receivers are again transposed so that the original normal receiver is again on-line and finally the remote transmitters are again switched so that the normal transmitter is back on-line. This switching sequence (i.e., (AA)(AB)(BB)(BA)(AA), etc.) continues until normal service is restored at which time the switchovers cease.

A known problem area exists in connection with the automatic multiplexer switchover as implemented in the FKV. If a radio fade or problem causes the switch to assume that a multiplexer malfunction has occurred, the switchover sequence will begin. At a later time when the radio link has recovered, the switch assumes that the removal of the malfunction was due to the multiplexer switching and the Tx/Rx multiplexer configuration will remain in the configuration which existed when the radio link recovered. Thus, a radio fade could cause erroneous multiplexer switching from normal to standby units. The terms normal and standby, and Unit A and Unit B are used synonymously.

In subsequent usage, a T1-4000 is defined as two transmitters, two receivers, and a single switchover unit.

AN/FRC-162 FM radios are employed to transmit the T1-4000 partial response signal between the high-level multiplexers at various locations. The AN/FRC-162 Radio Set is composed of two transmitters, two receivers, an Rx transfer switch, and a Tx transfer switch.

In normal operation, the radio sets are operating upon traffic on parallel paths, even though only one is in actual use. Automatic switching of the transmitters is performed if loss of pilot, AFC, or RF power occurs. Receiver switching is performed upon loss of pilot or a reduction in received signal level (derived from AGC) below about -66 dBm, if the standby receiver has 5 dB better received signal level (RSL).

As shown in Figure 2-2, user breakouts are made at four of the six FKV sites; namely HDG, KSL, SGT, and VHN. The potentially unmanned site at SWN is simply a radio baseband repeater. STB is a combined repeater and digital regeneration site where the function of digital regeneration of the signal is accomplished by back-to-back T1-4000s. Employing T1-4000s for regeneration of the signal at STB allows for possible future user breakouts at that location.

2.1.1.2 Orderwire

Between the respective FKV sites, two channels are available for voice and data communications. As shown in Figure 2-3, the frequency range from approximately 400 to 3600 Hz can be used for voice communications. This voice channel or Maintenance Coordination Circuit (MCC) is broken out at HDG, KSL, STG, and VHN as depicted in the representative diagram of Figure 2-4. At the potentially unmanned sites at SWN and STB, a bridge-on is employed such that the MCC is a party line and the MCC at these sites connects with both adjacent sites. Also, the sites on both sides of the unmanned sites may communicate with each other directly.

A portion of the upper frequency band from approximately 4400 - 7600 Hz is used to transmit alarm data by means of the Fault Alarm Status Reporting (FASR) system from the SWN and STB sites to the FKV sites on either side of these locations. As illustrated in Figure 2-5, the FASR employs 60 Hz FSK about the center frequency of 5 or 7 kHz. Hence, the bandwidth from approximately 5300 Hz to 6700 Hz is available for additional telemetry.

The actual alarm scanning function is performed by a Pulsecom Datalok-7 Remote Alarm Telemetry Unit. This unit scans the alarms, multiplexes their status into a serial bit stream, and FSK modulates a 5 or 7 kHz carrier as previously discussed. Both the 0-4 kHz channel and 4-8 kHz channel are combined in the radio and then FM modulated on an 8.1 MHz subcarrier before being combined with the partial response signal from the T1-4000.

After FM demodulation, the receiver baseband output is simultaneously applied to the overhead channel demodulator and to the receiver T1-4000 input. The output of the FDM overhead channel demodulator is routed to the VOW filter and to the Datalok-7 where FSK demodulation and demultiplexing is accomplished.

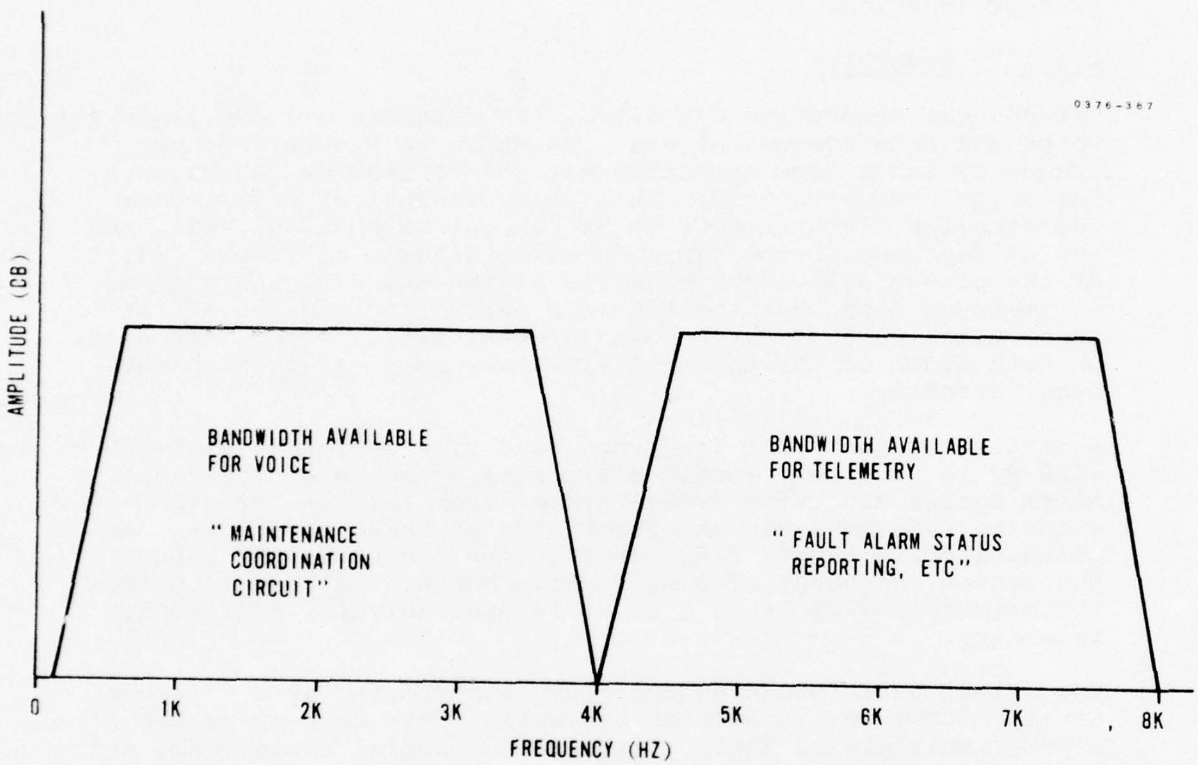
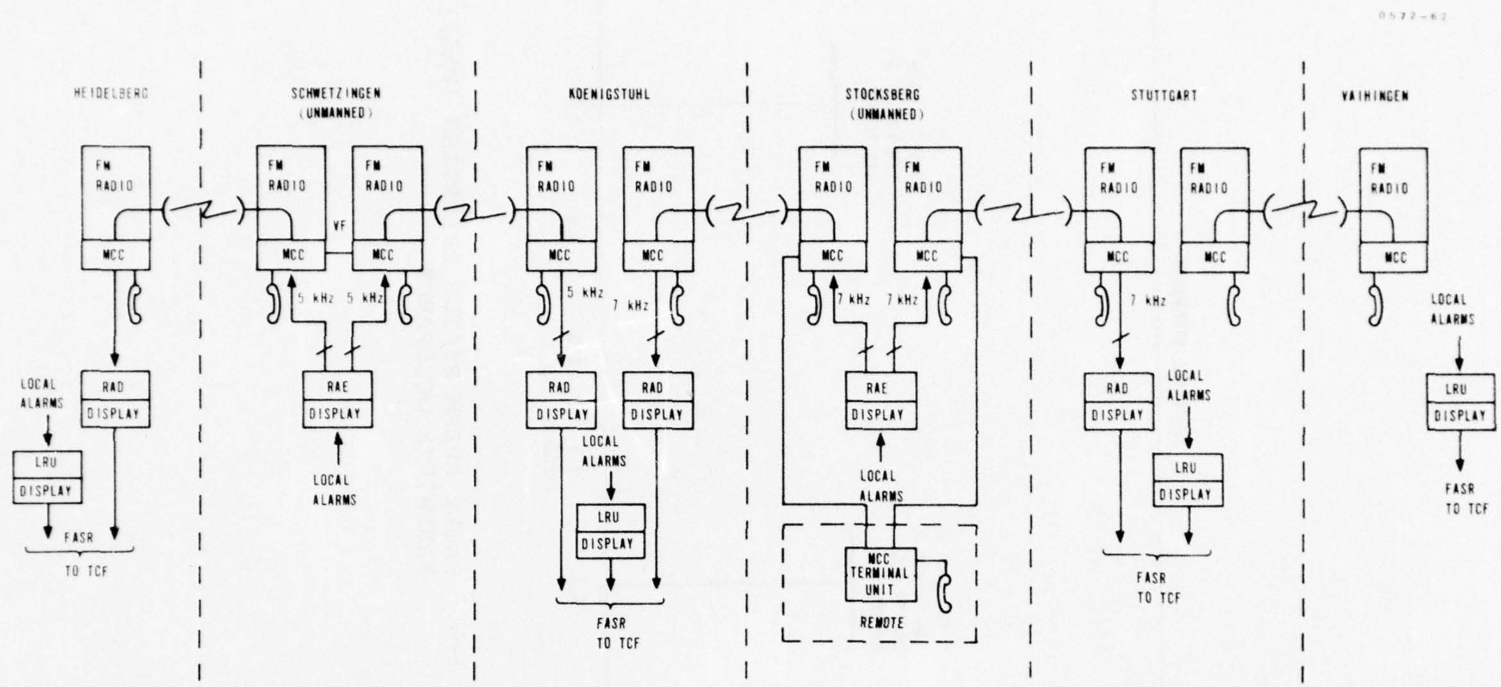


FIGURE 2-3. VOICE ORDERWIRE/COMMUNICATIONS CIRCUIT



LEGEND
LRU - LOCAL RELAY UNIT
FASR - FAULT ALARM STATUS REPORTING
RAD - REMOTE ALARM DECODER
RAE - REMOTE ALARM ENCODER
MCC - MAINTENANCE COORDINATION CIRCUIT

FIGURE 2-4. PHASE I FKV ORDERWIRE CONFIGURATION
(VOICE CHANNEL AND FAULT ALARM STATUS REPORTING SYSTEM)

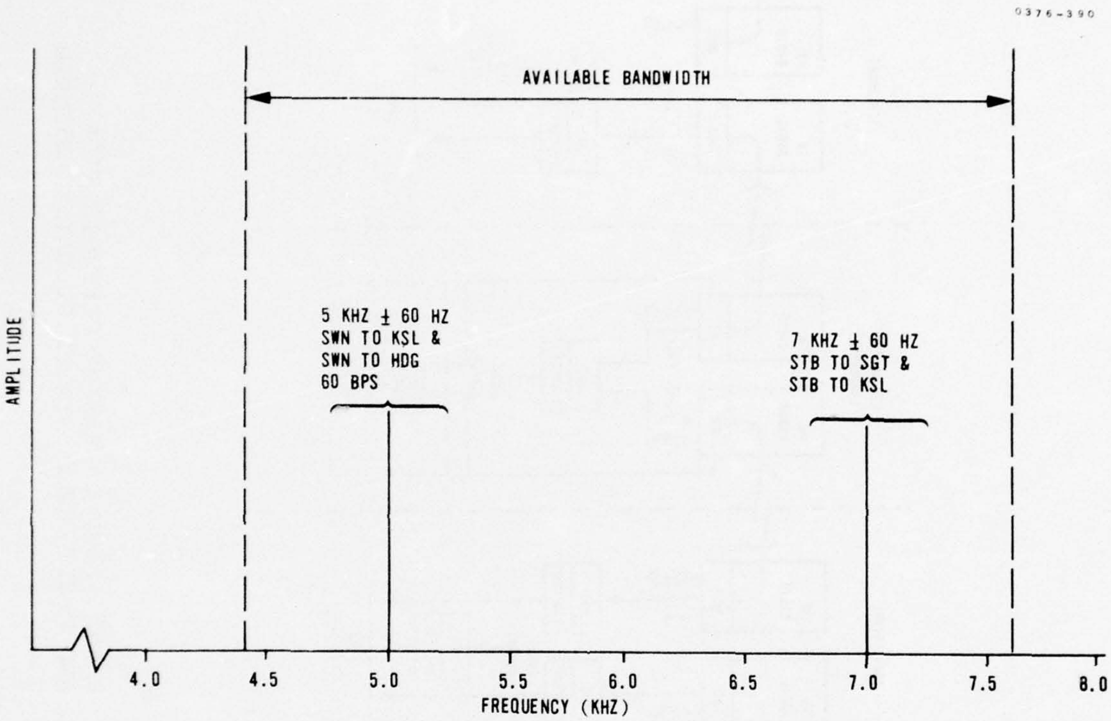


FIGURE 2-5. FAULT ALARM STATUS REPORTING (FASR) BANDWIDTH OCCUPANCY

2.1.2 FKV System-Level PA/FI/TA Considerations and Requirements

2.1.2.1 User Interface

The user interfaces with the FKV digital transmission system may be either analog or digital. Each user has a set of parameters which he uses to set a level of acceptance for the quality of serivce being provided. Table 2-1 lists those parameters felt to be of concern to the backbone system users. These parameters were selected, for discussion purposes only, since they have the greatest impact on fidelity or accuracy of traffic reproduction. Inspection of the list illustrates the widely ranging requirements of both user types.

A main commonality between these user service demands is that both agree on Availability as being high on the list of requirements. The transmission system type used (FDM or PCM/TDM) and the tech control requirements imposed on the system are of little concern, given that the user parameter requirements are satisfied and maintained, or in other words, that the system is available.

The tech controller interfaces to his users in the language of parameters native to the user, both analog and digital. It is, therefore, important that tech control continues to provide parameter measurements at the user interface which is consistent with the user parameter requirements. Simply, when talking to analog users, the FKV system tech controller should address those parameters of concern to him, like amplitude and delay response, distortion and noise, yet when talking to a digital user, bit error rate assumes primary importance among the parameters of interest. What does this all mean to the FKV system tech controller? Most importantly, it means that the need will continue for the foreseeable future to provide circuit-level measurements regardless of the type of backbone transmission system being used. Therefore, the circuit-level measurements currently being performed by tech control personnel on VF circuits have the same applicability to user interface measurements in PCM/TDM transmission systems as they currently do in an FDM transmission system, as discussed in the remainder of this section.

TABLE 2-1. USER CIRCUIT QUALITY PARAMETERS OF CONCERN

Analog Parameters	Digital Parameters
Availability	Availability
Signal/Distortion Ratio	Bit Erorr Rate
Impulse Noise	Percent Error-Free Seconds
Amplitude and Delay Response	Throughput

2.1.2.2 FKV System Parameter Usage

When established, parameters are used to define the boundaries between acceptable and nonacceptable performance of any system, equipment or device. To be useful, parameter values must be indicative of the quality of operation and must be readily translatable by technical controllers into references which permit them to make value judgment; i.e., to continue operation in the normal mode or select an alternate mode (use of standby equipment or circuits, links, nets, etc.).

In the FKV system, availability and performance margin parameters are of prime concern to technical controllers. The one describes the percentage of time the system is usable and the other the quality of its operation when referenced to some value established as a measure of optimum operation. Availability is also a measure of the quality of maintenance. Well maintained equipment will provide both more usable equipment time as well as longer equipment life. Performance margin may indicate the need for minor corrective actions (preventive maintenance such as calibration, replacement of air filters, etc.) which will prevent loss of signal, major breakdown or catastrophic failure.

DCS digital performance measuring parameters are listed in Table IV and described in Paragraphs 2.c.(1) through 2.c.(3) and Paragraph 2.d of DCEC Technical Report No. 3-74, Digital Transmission System Design, dated March 1974. The table is reproduced here as Table 2-2.

2.1.2.3 System Level Parameters

System-level PA/FI/TA considerations and requirements for the FKV may be based upon published digital system performance objectives such as those listed in Table 2-2. The specific DCS objectives have been translated by the FKV System Contractor into precise parameters for the FKV system and are documented in the FKV System Engineering Plan, Volume I, dated 30 August 1974. These translated values are shown as the first entry of Table 2-3 (FKV) and are compared with similar parameter values of MIL-STD-188-100, the Bell System and DATRAN Inc. (two major operators of digital transmission systems). As can readily be seen, by comparing the data in Table 2-3, there is no agreement or universality of the relative importance of the parameters or to what extent of precision they should be measured.

The function of the monitor system is not to modify the value of these parameters, but simply to measure them. System operators

TABLE 2-2. DIGITAL TRANSMISSION PERFORMANCE OBJECTIVES

Performance Parameter	Allocation Per LOS Hop	Allocation Per Digital Link	Total (Sub-System)	Total (12,000 nmi Circuit)
1. Availability	0.99995	0.99995^{N} (1)	0.99995^{Nn} (2)	0.99
2. Bit Error Rate	5×10^{-9}	$5 \times 10^{-9} N$	$5 \times 10^{-9} Nn$	5×10^{-6}
3. Error Free Seconds				99.99% (4)
4. Bit Count Integrity (mean time to loss of)		24 n hours	24 hours	
5. Jitter				
a. Maximum Departure (3)	1/4 bit interval			
b. Short Term Stability of Bit Timing Rate	$\frac{1 \times 10^{-2}}{N}$	1×10^{-2}		
6. Noise (equivalent PCM noise)		316 pWp0	316 pWp0	3160 pWp0

1. N is the number of LOS hops in the digital link.

2. n is the number of digital links in the subsystem.

3. Maximum departure from nominal transition time at the timing recovery and regeneration point.

4. Being considered for digital data services.

TABLE 2-3. AVAILABILITY/BER REQUIREMENT COMPARISONS

FKV

- BER $<7 \times 10^{-8}$ less than 0.01 percent of hours at T1-4000 12.6 Mb/s input port.
- End to end BER $<3.5 \times 10^{-7}$ 99.99 percent of time as measured at 12.6 Mb/s TDM input port.
- BER radio and multiplex $<1 \times 10^{-7}$.

MIL-STD-188-100

- BER $<1 \times 10^{-5}$ for >99 percent of time for 12K mile circuit.
- BER $<1 \times 10^{-6}$ for >99 percent of time from tech control to tech control 12K mile circuit.

BELL

• Availability	99.96 percent of time
• % Error free seconds	99.5 percent of one second intervals error free

DATRAN

• Availability	99.98 percent
• % Error free seconds	99.95 percent
• BER	$<1 \times 10^{-7}$

and/or tech controllers can then use the measured values in conjunction with system operation requirements to establish valid baselines against which system performance can be evaluated. Noting that the monitor system should be capable of accurately measuring parameter values over the useful range of each particular parameter, the present concern lies in the multiplicity of candidate system-level parameters and not their values.

Table 2-4 summarizes the system-level parameters currently in use by the cited operating agencies and those considered useful by this study. Except for jitter, all are useful at the system level in the FKV. As explained in detail in Volume II, due to the basic jitter, which is inherent in an asynchronous digital system, the jitter present at the various equipment interfaces is not a meaningful measure of equipment performance or performance margin and will not be considered as a system-level parameter.

In addition to the system-level parameters previously presented, a new parameter designated as "performance margin" is given. This parameter is intended to be a measure of the allowable degradation between the normalized system operation and an unacceptable condition of system operation. Examples of system parameters which may be used to derive the measure of performance margins are, partial response eye pattern scatter, received signal level, or a combination of these two parameters.

The system-level parameters that are considered useful for PA/FI/TA of the FKV system were selected on the basis of their usefulness to measure the health (optimum operating efficiency) of the FKV system.

The selected parameters and there values are:

Parameter	Description	Usefulness
Availability	The fraction of time that a system is actually capable of performing its mission. (Normally expressed as a percentile.)	A system parameter capable of being estimated through the measurement of parameters such as RSL and baseband eye noise which enables a comparison to system design objectives, thereby contributing to system performance assessment.

TABLE 2-4. DIGITAL TRANSMISSION SYSTEM PARAMETERS

System Parameter	Bell	Datran	DCS	Honeywell
Availability	X	X	X	X
BER		X	X	X
% Error Free Seconds	X	X	X	X
Bit Count Integrity			X	X
Jitter			X	
Noise (Equivalent PCM)			X	X
Performance Margin				X
Throughput				X

Parameter	Description	Usefulness
BIT ERROR RATE	The ratio of the number of bits incorrectly received to the total number of bits sent.	A parameter useful in determining transmission system performance from measured BER at monitor points such as the radio baseband, T1-4000 and T1WB1. Usefullness is: Performance Assessment: Measurement of BER contributes directly to a measure of system operation. Performance Margin: Comparison of the measured BER referenced to a degradation threshold yields an operating margin useful in determining the system reserve capacity. Fault Isolation: Measurement of BER and comparison to a threshold contributes to the fault isolation capability. Trend Analysis: Long-term statistics on measured values of BER enable detection of gradual degradation.
BIT COUNT INTEGRITY	That condition in which the precise number of bits that are originated per unit of time are preserved.	Useful during fault isolation as a possible cause for multiplexer reframe activity.
Noise (PCM Equivalent)	Channel-level noise caused by the error of approximation.	A channel-level parameter of limited usefulness for performance assessment but of use during fault isolation in detecting analog-to-digital converter problems affecting channel noise.

Parameter	Description	Usefulness
Performance Margin	The difference between the operating point and that point at which the system is incapable of performing its mission.	This parameter enables detection of system or equipment degradation prior to the point at which such degradation would affect performance. Examples of such parameters are RSL and baseband eye noise.
Percent Error-Free Seconds	The ratio of the number of seconds that information is correctly received to the total number of seconds that information is sent, times one hundred.	A system parameter contributing to performance assessment by measuring periods of acceptable performance.
Throughput	The number of error-free blocks passed through the system.	A system parameter contributing to performance assessment by measuring the amount of useful blocks passed by the system.

These parameters, describe the performance quality of any digital transmission system. This study is directed toward the most effective means of measuring, analyzing, and quantifying these parameters and their relationship to the FKV system performance.

2.2 MONITORING SYSTEM CONSIDERATIONS AND REQUIREMENTS

2.2.1 General Considerations

The monitoring problem addressed herein is that of central monitoring of a communications network composed of unmanned or minimally manned sites. The FKV network is used as a model upon which to conceptually develop a monitoring discipline.

The main driving force for central network monitoring is reduction of total numbers of personnel and particularly of skilled personnel. The role of the monitoring system is to collect and organize information in a manner which optimizes the use of human resources.

The monitoring system must serve the needs of at least three functional groups: technical control, maintenance, and system management. Within these groups, various levels of skills will exist, all of which should be able to derive useful assistance through monitoring.

The functions which the monitoring system performs can be classified as fault detection and fault isolation, performance assessment and performance margin,degradation detection and isolation, preventive maintenance measurements, and site alarming. These terms will be defined as used herein.

A fault is the inability of the system to meet user's minimum needs or to provide essential standby capability. Service faults are conditions of no service, continually disrupted service, badly degraded service, unusable signal-to-noise ratios, or high error rates. Redundancy faults are loss of capability in standby system elements whose function is to provide service in case of failure of the operating element. Fault detection is determination of the existence of these conditions; fault isolation is determination of the causative system element.

Performance assessment is determination of the degree to which the system and its elements are achieving intended performance criteria.

Performance margin is the measure of reserve capability to maintain intended performance in the presence of externally caused perturbations.

Degradation is performance somewhere between the "fault" condition and designed performance. Detection is determining that degradation exists; isolation is determination of the causative system element.

Preventive maintenance measurements are measurements of quantities which, in themselves, are not measures of system degradation, but whose own degradation potentially foreshadows system degradation or failure.

Site alarming is the detection of an abnormal condition in the site or equipment supporting the communications system.

2.2.2 Fault Detection and Isolation

Detection of a fault can occur through notification by the customer or through the monitoring system.

Requirements for the fault detection, verification, and isolation process are determined by the actions taken by network control personnel, upon learning of the presence of a suspected fault.

Verification that a fault really exists is usually desirable, although sometimes trivial. Having established the existence of a fault, the next step for network control is determination of the action to be taken. This involves assimilation of the available information about the location and nature of the fault.

Available alternatives are:

1. Pass responsibility to another organization.

2. Wait for the fault to cure itself.

3. Repair the cause of the fault.

4. Provide alternate service.

Assignment of responsibility for correction or circumventing of the fault to another organization is the appropriate action if the problem lies outside of the domain of responsibility of network control. Examples of situations where this action is appropriate are problems whose source lie in another network, and problems originating in equipment for which the user has operating and maintenance responsibility.

Waiting for the fault to cure itself is appropriate action if the source is a transient phenomenon. Radio system fades and transients caused by switching of power lines fall in this category. In the FKV digital network, use of station battery power supplies will reduce the incidence of power supply transients.

Repair of the fault, if within the network, involves the maintenance function. If its source is at a remote site, network control needs to know what site and what type of personnel to send. If considerable time is projected to be required for fault correction, provision of alternate service may be required. Prepared alternate routing plans are at times appropriate; in other situations individual action, on a circuit-by-circuit basis, is required.

The time scales involved in assessment of these courses of action and in implementing those chosen, weighted by cost and reliability considerations, govern the requirements for celerity

in fault detection and isolation. Specifics of fault detection/isolation for FKV are discussed in Volume III, Paragraph 2.9.3.

Implementation of all of the available alternatives for service restoral is manual. Transfer of responsibility involves orderwire coordination. If the fault is judged to be self-healing, the actions taken are those which will verify that the system has returned to normal. Alternate routing requires manual patching and orderwire coordination. Maintenance action requires dispatching the right people to the right location with the right equipment. The speed with which a fault is reported can, therefore, be many seconds without substantially affecting the total response time. The major contribution of the monitoring system is to provide reliable information upon which network control can base its action, organized in a manner in which cause and effect relationships are apparent.

2.2.3 Performance Assessment and Degradation Detection/Isolation

Performance assessment is the determination that the system, and its elements, are achieving the design performance criteria. It is measured on a zero to one scale; i.e., failure to optimum. Performance assessment should provide the same measure of the performance that the transmission system provides to the user. Direct, continual, and conclusive measures of this performance are not possible in most situations. In other situations, they are possible, but expensive, complicated, and impose a duplication of capabilities already possessed more straight-forwardly by the user. An example of this is the AUTODIN Switch, which generates considerable data on interswitch trunk performance.

Additionally, not all users possess this degree of sophistication, or possessing it, are unwilling to release data on a timely, non-adversary manner. Since the objective of the system is user service, and since personnel operating the network must deal with users, some inferential information about the service provided is needed. Knowledge of the grade of service provided to the user, however, provides no insight into what measures should be taken to improve that service if degraded. To this end, degradation detection/isolation is an objective of the system.

Specifically, system-level performance assessment should provide hard knowledge which enables the tech controller to determine if the system is operating within its prescribed tolerances or levels of quality and, if not, then it should provide hard information as to how far out-of-tolerance operation is and

in what direction deviation has occurred. Furthermore, the performance measurement/assessment information should enable the operator/maintainer to deduce (degradation detection) the probable cause of the out-of-tolerance condition. The operator/maintainer can then use this information to perform the necessary actions to find out where in the circuit (link, equipment, channel) the degradation has occurred (degradation isolation). Dependent upon the amount of degradation which has occurred, audible and/or visual alarms can be used to attract the attention of the operator/maintainer, further ensuring the early detection of degraded system performance.

2.2.4 Propagation and Detection of Degradation in the Digital System

Figure 2-6 shows a simplified representation of one direction of transmission of a digital system. The opposite direction is not shown. At the lowest level, in the left, is the assumed digital input to the system; on the right the output.

2.2.4.1 Effects of Errors

Any bit errors introduced by the transmission system, upon the users bit stream, between these input and output ports, will be reflected in the output. Furthermore, if the subchannel traffic approaches statistical stationarity, and in many cases even if it doesn't, errors are equally likely in the bit streams of other channels on the same transmission path. Bit errors introduced at the T1 level in the link from A to C are equally likely to occur in the framing bit as in any bit in the frame (again assuming a near-random bit stream). Thus, the probable error rate in the user's bit stream is equivalent to the framing error rate, and all users can be expected to be equally affected. Thus, over a period of time, errors introduced into the transmission system between A and C can be expected to affect equally all A-to-C users. If such is not the case, the first place to direct attention is to the equipment and systems peculiar to the affected channels, and not to the common elements.

For example, if there were four T1 channels going from Site A to Site C, and if they had different frame error rates, the parts of the system peculiar to the mux channel containing the T1 data are most suspect since the T1 level framing errors would be propagated from transmitter to receiver.

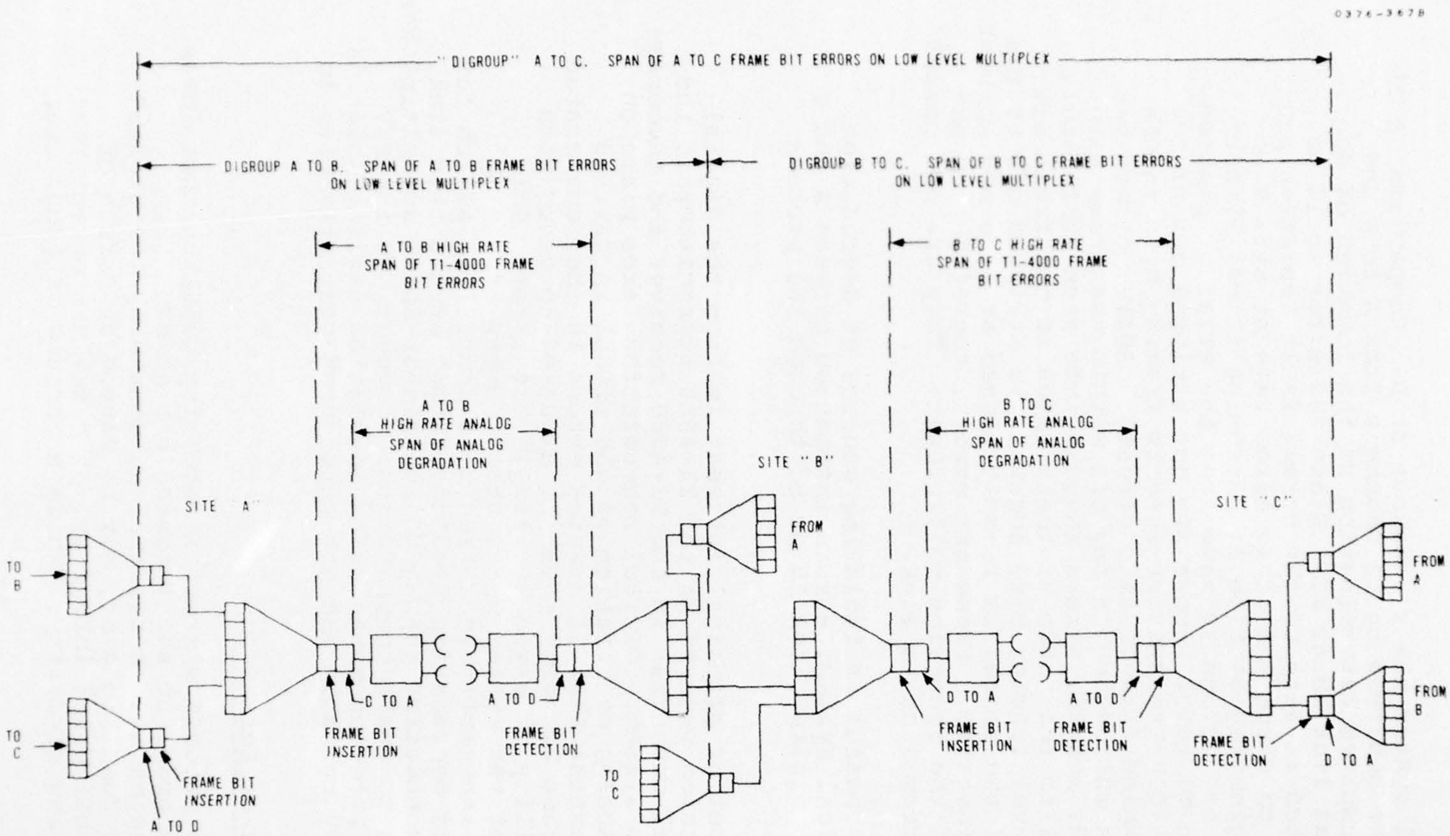


FIGURE 2-6. DEGRADATION SPANS AND RELATIONSHIPS

Our hypothetical system has a breakout at B. Comparison of T1 frame error rates observed on T1 channels from A to B and A to C allows a presumptive determination of the location of degradation in digital link AB or BC. Since the error would be initially detected at Site C, the normal fault isolation procedure would be to check the frame error rate at Site B on T1 channels originating at Site A. Assuming it was without error, then the assumption is made that the error originated at Site B, since T1 level errors are not stripped out of the system. The T1-4000 transmitter inserts framing bits in the bit stream assembled from T1 rate streams. Again, errors can be assumed to be introduced in any bit within the frame with equal likelihood, and the errors induced into each subchannel are proportional to the ratio of their rates to the frame bit rate. The T2 level framing bit, however, is stripped off at the receiver and, if the signal is re-multiplexed at B, a new correct framing bit is inserted. Frame bit errors, therefore, do not propagate beyond the receiving multiplexer. They are not passed down the chain from link to link.

This property is useful in isolating sources of degradation. In the hypothetical system, errors introduced between A and C can be traced to digital link AB or BC through the process described above.

The analog channel of principal interest is from the digital-to-analog conversion process in the T1-4000 transmitter to the analog-to-digital converter in the T1-4000 receiver and encompass the entire radio system. Digital regeneration takes place on the receiver. Analog degradation of the signal is carried through to the extent that it creates errors in the regenerated stream. Main frame bit errors can be expected to occur with the same probability as any other single bit error. This characteristic of the system means that sources of analog degradation are inherently localized to a link. The search for sources of analog degradation need not extend beyond this link. The lines interconnecting the lower- and higher-level submultiplexers are also subject to analog degradation. However, in the FKV system they are interconnected using in-station cabling which is presumably highly reliable and not considered cost effective to monitor.

2.2.4.2 Effects of Reframes

A reframe is the process whereby a receiving demultiplexer loses knowledge of the order of the incoming bit stream, then subsequently regains it. A reframe, as sensed by the digital circuitry of the demultiplexer, may be caused by bursts of errors; loss of bit count integrity, or a failure of internal timing and counting circuitry. While a reframe is occurring,

the output of the demultiplexer will be unrelated to the input. A burst of errors will occur and, in the asynchronous multiplexers (Tl-4000), bit count integrity may be lost. Timing transients may occur in the Tl-4000 output ports due to improper stuffing. Reframes will not progagate from a Tl-4000 receiver feeding a Tl-4000 transmitter (as at Station "B") since the transmitter generates a new main frame independent of the usefulness of the input data. Under such a condition, the bad data (data generated during Tl-4000 reframe) would be transmitted to Site C, processed by the Tl-4000 receiver, and passed to the receive lower-level multiplexer which would then alarm due to a loss of synchronization. Under conditions where a Tl-4000 reframe does not cause a loss of bit count integrity or exceed the resync time-out of the lower-level multiplexer (i.e., the CY-104) a loss of synchronization would be avoided, but the data transmitted during the Tl-4000 reference period would be lost.

2.2.4.3 Effects of Timing Aberrations

2.2.4.3.1 FKV System Timing Properties

Figure 2-7 is a functional block diagram of the FKV system timing relationships. In this diagram, all of the blocks in the bottom row represent sources of timing for some part of the system. Timing of a transmitting multiplexer and its companion receiver at the same site are completely independent. All transmitting multiplexers in the system, time their own output data. This timing is derived from an internal reference (which may be slaved to an external standard). At the left side of the diagram is the lower-level multiplexer, whose data stream is timed by the reference oscillator.

The Tl-4000 recovers the timing on each of its input ports through what is, functionally, a phaselocked loop whose neutral state is with the input buffer half full. The phase of this clock is compared with that of a higher rate clock derived from the Tl-4000 reference oscillator. When the system clock gets ahead by a predetermined amount, a dummy bit is stuffed into that channel, through the mechanism of not reading out the input buffer. In this manner, timing differences between the lower- and upper-level multiplexers are converted into stuff bits.

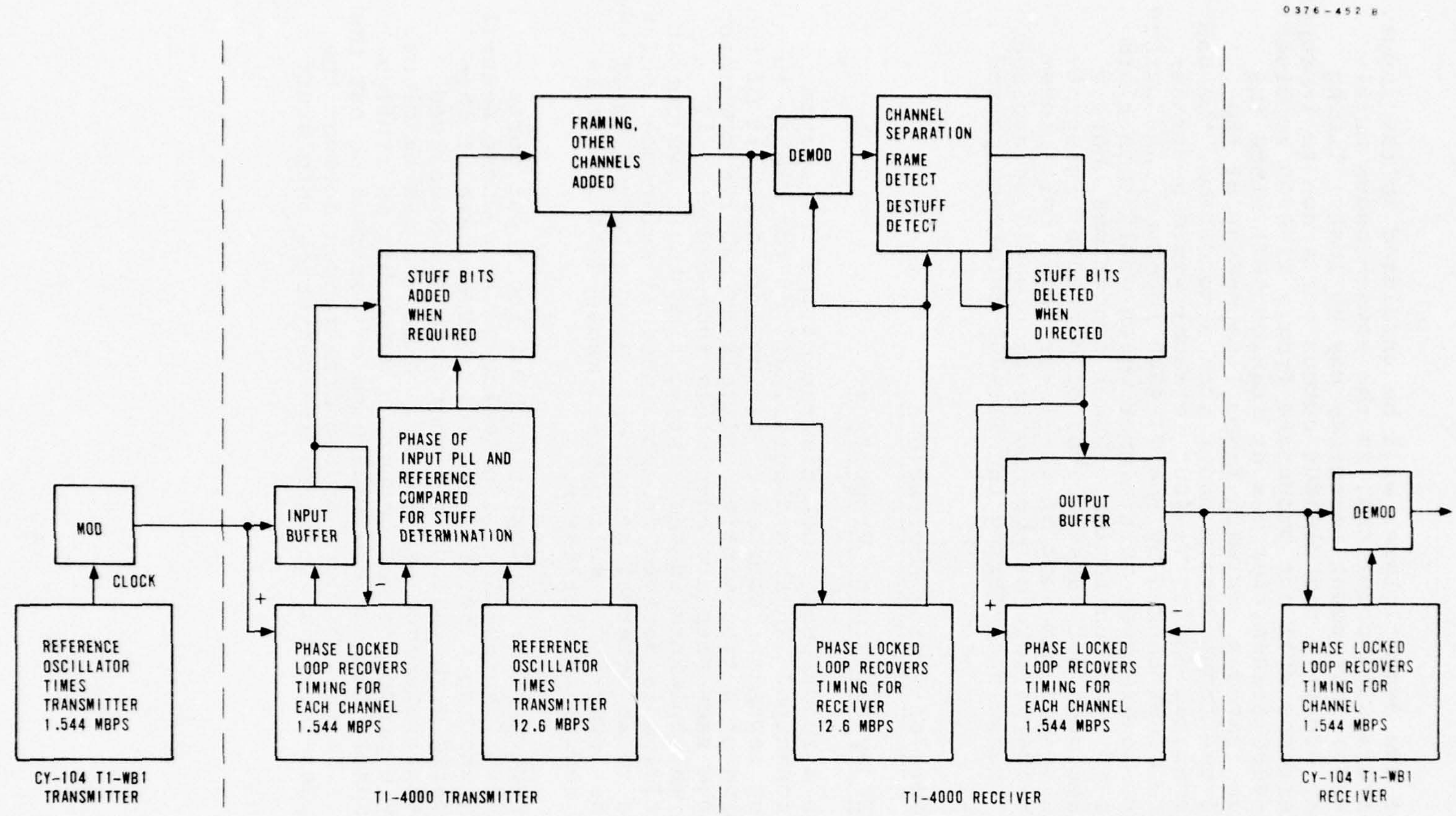


FIGURE 2-7. FKV TIMING AND STUFFING RELATIONSHIPS FUNCTIONAL BLOCK DIAGRAM

At the T1-4000 receiver, another phaselocked loop recovers the high rate clock. The individual channels are separated, and data is read into the output buffer. Bits which the stuff control instructions say "ignore" are not clocked into the output buffer. Around the output buffer is another phaselocked loop whose function is to smooth the timing fluctuations introduced by stuffing, and whose neutral position is with the buffer half full. This provides the timing for the output data line.

The lower-level multiplex receivers use a phaselocked loop to recover timing from input data, and use it for basic timing.

2.2.4.3.2 Propagation and Probability of Timing Aberrations

a. Frequency errors in reference oscillators are translated into stuffs in normal operation or into errors in abnormal operation. However, the required accuracy (5 parts in 10^5) is well within the state-of-the-art for inexpensive crystal oscillators.

b. Phase jitter is frequency modulation of the data stream. It can be introduced on the channel, or by the phaselocked loops which retime the signals.

Phase jitter can be introduced into the data stream between the T1-4000 equipments by the radio system. If so, it most probably would be at the frequency of the switching regulators in the power supply, a frequency which the receiver cannot track, and which thus would decrease its effective tolerance to fading. This is an improbable, but possible source of degradation.

At the T1-4000 output buffer, phase jitter is normally introduced by the loop's reaction to the destuffing process. Measuring phase jitter at these T1 output ports is, therefore, monitoring the operation of the channel timing recovery loop.

In the FKV, the lines between the upper- and lower-level multiplexers are in-station cabling, which cannot introduce jitter except under wildly imaginable conditions.

2.2.4.3.3 Conclusions

The conclusions drawn from this analysis are the following:

a. At the lower levels of the system (1.544 Mb/s and below) phase jitter is an unrewarding parameter to monitor operationally. Because equipment interconnections are

wire pairs, the transmission system will not introduce jitter. This measurement then becomes one of the measurements of phaselock loop characteristics which, in practice, can be expected to operate within system requirements, and whose most probable degradation mode is failure, in which case gross loss of service alarms will detect the problem.

b. Measuring stuff rates in the T1-4000 multiplexer is equivalent to measuring the relative accuracy of two crystal oscillators and is, therefore, unrewarding from an operational point of view.

c. Jitter which might be introduced into the T1-4000 partial response signal by the radio link can be monitored indirectly as part of a composite performance margin measurement (baseband eye pattern), as referenced in Volume II, Paragraph 2.2.4.

2.2.5 Performance Margin Assessment

Performance margin is a measure of reserve capability to maintain intended performance in the presence of externally-caused perturbations. In the case of a line-of-sight (LOS) radio system, performance margin is expressed as the fade margin of the system. Fade margin is the amount of transmission loss which can be tolerated between transmitter and receiver before performance falls to some predefined threshold. In digital systems, such as the FKV, this threshold is often called "PCM" threshold", and is the received signal level corresponding to a specified error rate at the A to D converter which recovers the digital signal. The radio procurement specification for the AN/FRC-162 sets this threshold at -71 dBm received signal level for a 10^{-7} bit error rate.

Link performance criteria, as described in Appendix A5, Item 4.c of Paragraph A5-2.3.1, includes the parameter "time below threshold". As is discussed in Appendix A5, the time below threshold of a space diversity system with identical receiving systems is proportional to the square of the power at that threshold. A three-decibel increase in threshold will, therefore, double the time below threshold of each leg of a diversity system, and quadruple that time for the combined systems.

Loss of fade margin can be classified as due to one or more of three types of occurrences.

a. Signal loss: This may be caused by obstacles in the line-of-sight path, or by deterioration in the common transmitting system waveguide antenna system.

b. Power added to the desired signal: Examples of this are an increase in receiver thermal noise or radio frequency interference adding to the signal.

c. Multiplicative distortion of the signal waveform: Examples of this are waveform distortion caused by intersymbol interference or by nonlinear amplitude transfer characteristics. Departure of timing from ideal, caused by phase modulation of the baseband, can also be considered in this category.

Methods of detecting the conditions encountered above will now be considered.

a. Because the radio transmission loss is a varying quantity, due to selective fading, rainfall fading, and normal scintillation, no single, randomly selected measurement is adequate for determination of loss. Two methods are available for determination of this condition.

b. One is to simply measure the loss under the condition for which it is defined. This entails making the measurement at a time when atmospheric anomolies are least. The usual reference conditions are in early afternoon, in a nonstratified atmosphere, without precipitation. A series of readings taken in these conditions, which shows a trend, will be a rather positive presumptive indicator.

c. If the meteorological verification required for reference measurements is not deemed feasible, then the less direct tool of long-term statistics is available.

Determination and separation of the other two sources of threshold loss requires consideration of their effects in producing errors.

The classic method of referring to system performance, as sensed by an analog-to-digital demodulator, is in terms of the "eye opening," which is discussed in detail in Volume II, Paragraph 3.2.2. The individual departures of the actual voltage

presented to the demodulator from the ideal condition are degradation. They may be considered as a degradation voltage superimposed upon the ideal signal voltage. The degradation voltage may arise in the manner cited, generically, above.

Multiplicative distortion will be, except in the depths of severe multipath fading, for practical purposes, independent of signal level. Its error voltage will have, in most cases, a non-Gaussian density function.

Power added to the radio frequency signal will, effectively, add noise to the radio frequency signal. This creates an increase of noise voltage at the receiver output. The absolute increase, unlike the general situation of multiplicative distortion, is through the FM process, a function of the received carrier level. The relative increase at all signal levels is a constant ratio, or a fixed number of decibels. Additive power may or may not have a Gaussian amplitude distribution. It will if the added noise represents an increase in receiver front-end thermal noise, or a co-channel FDM signal. It will not if the cause is, for example, a single frequency signal.

The manner in which multiplicative distortion and additive noise combine to produce an error signal in the baseband is analogous to the equivalent process in FDM systems in which intermodulation distortion and receiver thermal noise combine to produce idle channel noise. In FDM systems, operating at high carrier to noise ratios, idle channel noise is produced through the distortion mechanism operating on many independent sources and is thus, essentially Gaussian in nature. In the TDM system, the distortion mechanism operates primarily in the same manner.

The nature of the problem is illustrated by Figure 2-8, a plot of typical relative noise and distortion power versus received signal level, for: 1) a normally operating system, 2) system degradation, 3) noise degradation, and 4) combined system and noise degradation. The system will, most of the time, be operating at high RSL, on the right hand side of the plot where system degradation overwhelms noise degradation. Yet, in terms of its contribution to loss of threshold, the contribution of system degradation is negligible.

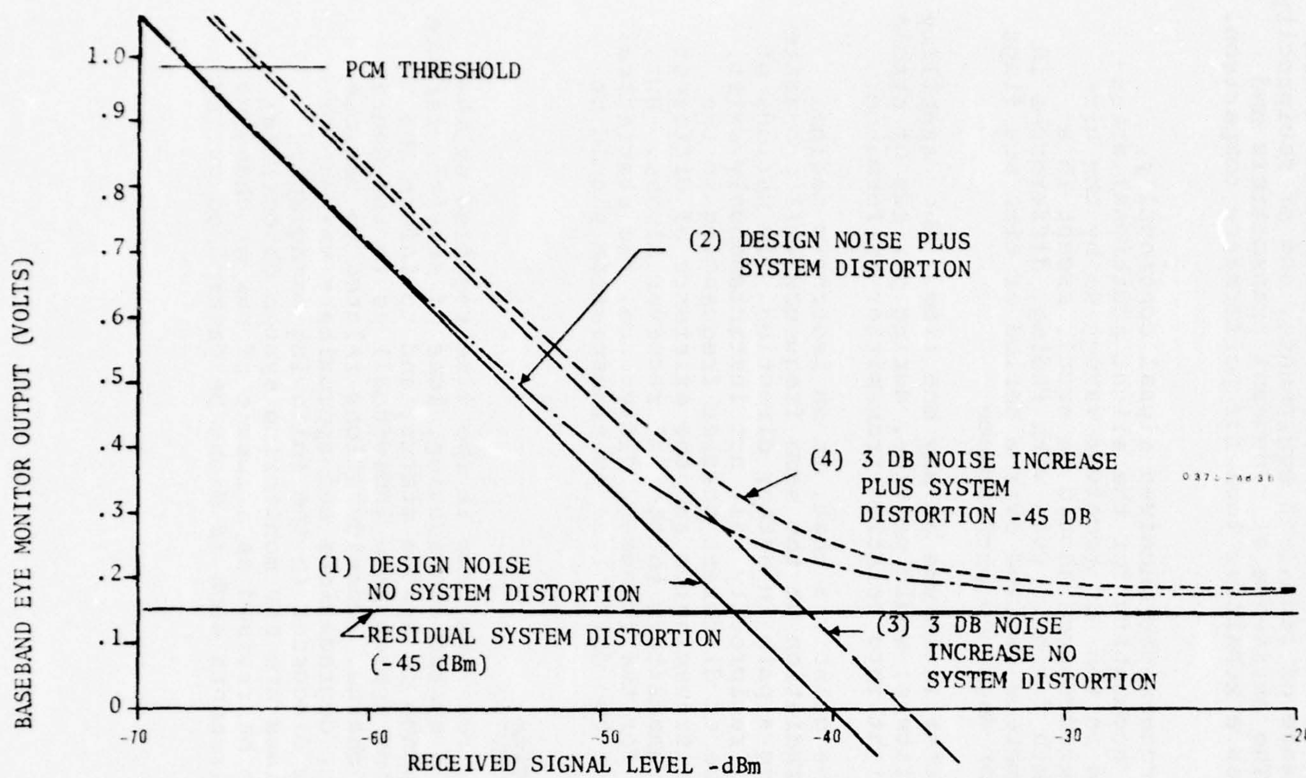


FIGURE 2-8. EFFECT OF DEGRADATION ON PCM THRESHOLD - TYPICAL

Any scheme for margin assessment should take advantage of comparative performance of redundant equipments, and of reciprocity relationships. The existence of redundant transmitters and receivers provides a sensitive tool for performance comparison.

Both receivers process the received signal continually. Therefore, after accounting for the slight additional attenuation introduced in the "B" receiver waveguide by the circulator, their performances should be equal, except in a period of multipath fading. Even with fading, differences in statistical parameters derived over a period of time are flags to investigate for degraded performance.

Only one transmitter is in use at any one time. The capability to switch transmitters, would provide, during periods of stable propagation, insight into relative transmitter performance.

Reciprocity is the principle that, in an isotropic medium, electromagnetic radiation at the same frequency will propagate equally well along a path in either direction. In periods of selective fading, reciprocity will not instantaneously exist, because of the use of different carrier frequencies in the two directions of transmission and the existence of different paths from the transmitters to the "A" receiver dishes. But, after correcting for the frequency difference, the statistical performance of the two directions of transmission should be equal.

2.2.6 Reaction Time

Monitoring system reaction time is the time required by the system to detect a system degradation, loss of service, failure or significant change in system status, and to inform the system operator (or appropriate individual) as to the degradation or status change. Considerations related to various system failures or degradations and approximate values for reaction time are discussed in the following paragraphs. These reaction times are FKV monitoring system objectives; however, they can be revised as a result of new or changing operational requirements such as might be determined during field testing.

Loss of service is the most significant system status change since, in this case, users are directly effected. Assuming that service may be restored or alternate routing effected at a manned site in a matter of minutes,a reasonable upper limit for detection of loss of service would be on the order of 30 seconds.

Loss of standby equipment is not nearly as significant as loss of service since the sytem users are not affected. Keeping in mind the human reaction time (inform maintenance, locate spare parts, fill out a trouble ticket, etc.) a reasonable upper limit to the detection of standby loss is 5 minutes. Indeed, when one considers the probability of the operating unit failing given that the standby failed, this limit could easily be increased.

Equipment degradation which does not result in immediate loss of service of acceptable quality falls under the classification of maintenance rather than system restoral. A plausable upper limit is now related to fractions of hours instead of minutes. A realistic reaction time upper limit to degradations is 30 minutes.

Circuit degradation by definition is not an overall equipment failure resulting in loss of service to many users. Also, in many cases, the degradation is of the extent that the circuit is usable. As a consequence, circuit degradation is less significant than equipment degradation in a monitoring system context. As such, circuit degradation has been exempted from reaction time considerations. From a cost-effective viewpoint, VF channel monitoring should be considered on the basis of a quality control service to users and for fault isolation between FKV and analog transmission systems rather than as a monitor for inferring digital degradation.

ATEC or monitoring equipment degradation does not affect the communication system performance. Indeed, given that repairs are necessary, the communication system certainly would be repaired prior to repair of the monitoring system. An upper limit to the reaction time to detect ATEC equipment degradation is one hour.

Telemetry degradation ranks somewhere between loss of service and loss of standby in significance since a telemetry degradation may render part or all of the monitor system unusable. Considering that software may continually monitor the status of an active telemetry system which employs parity checks, an upper limit to the detection of telemetry degradation is one minute.

In summary, the reaction time or required detection time upper limits are given below:

Loss of Service	30 seconds
Loss of Standby	5 minutes
Equipment Degradation	30 minutes
ATEC Equipment Degradation	1 hour
Telemetry Degradation	1 minute

2.2.6.1 Basis for Reaction Time Selection

The proliferation of unmanned communications facilities within the military communications system is the result of many factors. One of the primary causes, other than technical capability, is the sharp reduction in available manpower and the loss of skilled personnel, as well as journeyman level maintenance personnel. The development of the nodal tech control and maintenance facilities concept is a direct outgrowth of the current manpower situation as well as economic factors which impose the need for more efficient use of available manpower.

In the event of equipment failure or a maintenance requirement at an unmanned site, a maintenance technician must be transported from the nodal site to the unmanned location. Dependent upon the distance involved, type of transportation, road surfaces, terrain, time of year and weather conditions at the time of incidence, the average overall time to repair (OTTR) may vary from a relatively short time (approximately 2 hours) to a considerably longer time (> 20 hours). Although reaction time of the equipments used to monitor performance of operating equipments at unmanned sites must be much less than the OTTR, to keep repair time to a minimum, practicality and cost effectiveness dictate use of realistic values in establishing such reaction times.

For example, equipment Major Alarms which are indicative of loss-of-service can be monitored at a rate of 10 times per second, however, the amount of data collected (36,000 samples per hour/alarm) imposes unwarranted computer storage and processing requirements on the monitoring system. Similarly a rate of 1 minute or even 10 minutes could be postulated to effect reduction in storage and processing requirements. However, assuming an OTTR of 2 hours, which is equal to 7200 seconds, then a 30 second reaction time to loss of service is equal to 0.4 percent of repair time. When this reaction time is compared to overall repair time the additional equipment complexity for faster measurements can not be justified. The reaction times postulated in Paragraph 2.2.6 can all be justified, in a similar manner based on the type of fault and the

corrective action required. Loss of standby equipment does not mean loss of service, it only threatens such loss. Assuming the same OTTR of 2 hours, a 5 minute reaction time equals 4.0 percent, which is a very reasonable ratio from the viewpoint of practicality and cost effectiveness. Equipment degradation, to the point of loss of service, is a long term process, usually from weeks to months. Assuming a median time of two weeks or 20,160 minutes for degradation to the point of loss of service, the 30 minutes for reaction time equals 0.0015 percent. This certainly provides enough time to establish whether a measurement which indicates degraded performance is indicative of a trend or is a momentary aberration.

ATEC equipment is programmed to self test after every normal scan of the attached monitor points and provides the tech controller with a positive indicator of equipment performance. A green indicator for normal, amber alarms which indicate marginal performance and red alarms which indicate out-of-tolerance performance. The Test Alignment (TA) procedure provides performance data which indicates fractional variations from the operating norms. In all cases, other than catastrophic failure, a one hour TA measurement cycle provides more than sufficient time to determine if deviation from normal operating values are momentary or trending toward marginal performance with a requirement for corrective action. Since the ATEC equipments operate on a non-interfering basis and do not threaten loss of service a one hour reaction time is reasonable and cost effective.

Degradation of the FKV monitor system telemetry equipment is again a relatively long term process with respect to loss of service. However, since the telemetry equipment is involved in the transfer of performance monitor data which describe the condition of the operating equipment a faster reaction time is required than for the ATEC equipment. Again based on an OTTR of 2 hours or 120 minutes, a reaction time of 1 minute is equal to 0.8 percent of the OTTR. This is felt to be practical and cost effective with regard to the overall time involved.

2.2.7 Scan Time

The time required to scan a system parameter or make an observation is a function of the parameter type, mechanization of the monitor system, and the telemetry data rate. Scan times and scanning sequence for the FKV, are discussed in considerable length in Volume II, Paragraph 2.4. Within the reaction time constraints, scan cycle timing for candidate monitor system configurations can be established and trade-offs of varied telemetry data rates can be made. Implications derived from the trade-off of these variables are of great significance; Volume III, Paragraph 2.5, addresses the scanning analysis outcomes and advances specific recommendations for the FKV system.

2.2.8 Telemetry

For the FKV performance monitoring system, two basic telemetry configurations, denoted as private line or party line, are candidate approaches. In the private line configuration, each remote site is connected to the central site by one or more independent telemetry channels. For example, each site may utilize two channels, one for an alarm scanning and one for parameter measurement and control. In the party line configuration, each site represents a drop on a common party line. The advantage of the private line is speed of scanning as several sites may be instructed to perform tests or reply simultaneously. However, the private line requires more hardware due to more channels at the central site and also may place a higher demand upon the central processor due to a potentially higher return data rate. The party line suffers from a capacity limitation since only one party or remote site may be addressed and may respond at a time. Indeed, usually a second site may not be addressed until the first site has completed a reply for fear that the second site may respond before the first site has completed its response. An advantage of the party line is cost due to simplicity of hardware. The actual system employed may utilize a combination of the above two approaches. For example, the alarm scanning monitors may be on private lines while parameter measurement monitors may share a party line.

2.3 FKV MONITORING SYSTEM APPROACH

There are many factors to consider in designing a technical control monitoring system and consequently there are many possible approaches to the design. This section defines and establishes the need for performance assessment measurements and broadly categorizes general approaches to monitoring system design.

2.3.1 Digital Versus Analog Assessment

There are elements of similarity and dissimilarity in monitoring equipments for analog multiplex equipments versus those for digital multiplex equipments as typified, in particular, by those employed in the FKV transmission system. Structured functional parallelisms in monitoring requirements arise as the role of performance assessment is examined in congruence with the duality of analog distortion vis-a-vis digital error.

2.3.1.1 Principal of Uniformatarianism

There are two camps of opinion regarding the utility of performance assessment measurements for digital equipments as typified by FKV multiplexers. The camp which feels that PA measurements for the muxes can be dispensed with maintains that digital multiplex equipment failures can be expected to be hard failures and that, therefore, the monitoring system need only include hard-failure alarms for those multiplexers. However, experiences with other digital equipments belies the assumption that digital equipment failures are usually hard (gross) failures.

The ATEC equipment utilizes digital elements. Two typical examples are the militarized minicomputer, the H-316R, and at the large component level, analog-to-digital converters. Many times H-316R failures have occurred that cannot be described as hard and/or gross; however, it could be argued that a processor is more complex than a multiplexer and that experience with processor failures/degradations are not identifiable with multiplexer failures/degradations.

Be that as it may, ATEC experiences with A/D converters will suffice; A/D converters are found in CY-104s and may be used to illustrate digital equipment degradations. A/D converter failures can affect individual bits/gates such as the sign bit or any of the amplitude bits (there are 12 amplitude bits in ATEC A/D's). A sign bit error is relatively gross and is easily detected in the subsequent misoperation of the affected ATEC

equipment. The amplitude bits range from the most significant bit (MSB) to the least significant (LSB). Failures of an individual gate/bit becomes progressively more difficult to detect according to the significance of the bit affected with MSB failures being relatively easy to notice and bit failures on the LSB side being difficult to detect. Failures of any bit/gate can be, and have been, of the stuck bit/gate type or of the randomly "running open" bit flap type. Either of these types of failures, stuck bit or bit flap can be a hard failure or an intermittent failure. The most difficult failure type to detect is an intermittent bit flap for an LSB.

Gross hard failures can occur which affect all of the bits in the A/D ladder. This failure type is, of course, the easiest to detect. ATEC equipment periodic self-test routines eventually detect all of the failure types discussed.

We note that digital multiplex equipments deployed in the FKV are typical representative commercial equipments employing, in some instances, somewhat marginal logic timing designs and plastic encapsulated semiconductor/integrated-circuit components. While it may be true that the multiplex equipments operate reasonably trouble-free during infancy, there is no logic to the expectation that the FKV multiplex equipments will operate without an expectable degradation failure rate which will feature its full share of equivalent degradations, both hard and intermittent.

The principal of uniformatarianism, formulated years ago in the natural sciences, maintains that physical (failure) processes observed at work in the present and observable past are those that will be at work in the future. The principal of uniformatarianism argues in favor of the ultimate need for performance assessment measurements even for digital multiplex equipments in the FKV. Table 2-5 illustrates the sign bit and amplitude bits found in an A/D converter.

2.3.1.2 Law of Murphy

Murphy's well known law as applied to engineering endeavors maintains that if anything can go wrong it will.

While Murphy's Law is frequently the subject of jest, the experience of the ages shows that Murphy's Law is a pithy aphorism worthy of the utmost respect; any engineering undertaking which proceeds under the assumption that the law is inapplicable in a specific instance is foredoomed to failure or at least to significant reengineering.

Those who maintain that FKV system design is such that degraded operating modes in digital multiplex will not occur are disregarding Murphy's Law. Murphy's Law can, for a specific instance, be repealed but only from experiential evidence such that gained from several years of operation. Some space-launched equipment is heavily engineered through several development cycles. This equipment is the most reliable that has ever been produced and yet even here, failures hard and intermittent, have occurred.

The FKV equipments have not been as well engineered as typical space-launched equipments and there is no experiential evidence to preclude the application of Murphy's Law. In fact, installation difficulties indicate that FKV equipments are typical of other equipments of similar ilk.

TABLE 2-5. ILLUSTRATION OF AN A/D CONVERTER LADDER SHOWING SIGN BIT, MSB, LSB, AND INTERMEDIATE AMPLITUDE BITS/GATES

Bit No.	State	Interpretation
13	1 or 0	+, -, sign bit
12	1 or 0	Most Significant Bit (MSB) Amplitude Value = 2^{11} = 2048
11	1 or 0	Amplitude Value = 2^{10} = 1024
10	1 or 0	AV = 2^9 = 512
9	1 or 0	AV = 2^8 = 256
8	1 or 0	AV = 2^7 = 128
7	1 or 0	AV = 2^6 = 64
6	1 or 0	AV = 2^5 = 32
5	1 or 0	AV = 2^4 = 16
4	1 or 0	AV = 2^3 = 8
3	1 or 0	AV = 2^2 = 4
2	1 or 0	AV = 2^1 = 2
1	1 or 0	AV = 2^0 = 1 Least Significant Bit (LSB)

Therefore, it is concluded that FKV multiplex equipment will exhibit degraded modes of operation. Such degradations typically will not activate an existing alarm in the FKV equipment. Therefore, it is appropriate to consider performance assessment (PA) measurements for the multiplex equipments. Such PA measurements verify satisfactory equipment operation (by definition) and in so doing detect degraded (and grossly failed as well) equipment operation.

2.3.1.3 Performance Assessment Definition

A performance assessment (PA) measurement is one which verifies the satisfactory operation of a portion of a communication system. This definition may be contracted to "green equals green;" that is, when a PA measurement is within the green (or satisfactory operating) range, the portion of the communication system/equipment associated with the measurement is in fact, in a green state exhibiting satisfactory operation.

A typical example of a PA measurement in the FKV system is the measurement of framing error rate (FER) in the receiving portion of an on-line T1-4000 multiplex. A satisfactory (green) FER verifies that that portion of the FKV traversed by the framing bits is (green) working satisfactorily. This means that associated framing transmit circuits, radio system, and common T1-4000 frame bit receive circuits are performing satisfactorily. There is, of course, typically no indication of radio system performance margin available from a green FER measurement. Margin measurement is different from performance assessment and will be covered below.

Most measurements proposed for and included in communications monitoring systems are not of the performance assessment type; rather they are gross failure indicators. Examples of non-PA measurements are power supply alarms and/or power supply voltage measurements. When these parameters are not in alarm (i.e., green), they provide no information bearing upon the satisfactory operation of the system. As for instance, the power supply voltages may be at ideal values, but the equipment may be totally unusable due to the failure of a constitutive circuit processing the mission data stream.

Furthermore, no collection of non-PA measurements (as is sometimes proposed) provides a performance assessment verification. A communication monitoring system built around gross failure alarms may show a completely "green board" while, in fact, the state of a portion of the system may be red.

The fact that non-PA measurements, e.g., power supply voltages, will detect failures and degradations in the power supply system is irrelevant to the prime basic mission of performance assessment. Almost all non-PA measurements which have been proposed over the years feature the characteristic that red equals red.

The difficult challenge in monitoring system design is the discovery of appropriate PA measurements. Experience indicates that PA measurements tend to be more difficult, more expensive, and more difficult to engineer than non-PA measurements.

After the monitoring system is properly designed to incorporate PA measurements, then non-PA measurements can be added, as resources permit, if desired. However, it is generally true, and specifically true in the FKV, that non-PA measurements which play no essential role cannot be logically included when they contribute to the cost, complexity, and/or scan cycle time budget of the system.

A PA measurement of FER, for instance, will be in alarm when the power supply for the associated T1-4000 fails. Thus, the only possible role for a power supply alarm is to aid in the isolation of the T1-4000 failure to the power supply. This type of fault isolation is not relevant to prime basic mission discussed later. Once it is detected that the T1-4000 is failed for any reason, then the automated portion of the monitoring system has done its job. Isolation beyond the equipment level is a maintenance function and automated isolation is most likely not affordable in any case.

2.3.1.4 Performance Assessment Requirement

In order for an automated technical control system to perform the monitoring portion of the automated control, performance assessment measurements must be included. PA measurements are by definition the only ones which verify satisfactory system performance and are therefore basic ingredients which come before all others in resource allocation priority.

Performance margin assessments (PMA) measurements go beyond PA measurements. PMA measures the degree of degradation which can be endured before system performance is affected.

Microwave received carrier signal level (RSL) is a basic contributor to performance margin measurement for the radio system. In a properly adjusted system, many dB of RSL degradation may occur before any measure of PA, e.g., FER, is affected.

Inasmuch as PMA measurements may indicate impending degradation before it is actually experienced, PMA measurements are valuable and are second in resource allocation priorities to PA measurements.

In a system, such as the FKV, wherein it is proposed that, eventually, significant destaffing will occur, it is of paramount importance that maintenance and control actions occur in a proceduralized, pre-planned, anticipatory if possible, manner since men will not always be conveniently available for spontaneous reaction to precipitous failures/degradations.

Thus it is concluded that PMA measurements are second only to the requirements for PA measurements. In descending order of procedural importance to maintaining operational conditions are the following:

Degradation Detection (D/D). The detection of degradation within the communications system would normally occur as a result of comparing PA/PMA values to a baseline reference. The detection of such degradation will initiate degradation isolation.

Degradation Isolation (D/I). This is a series of manually controlled measurements and tests which would isolate the cause of degradation to a particular link, site, and/or equipment within the communications system. (Refer to Paragraph 2.2.4, Volume I, as an example of D/I). The completion of D/I initiates the next step which is fault detection.

Fault Detection (F/D). This is the procedure whereby degraded performance is defined with respect to type, i.e., reduced signal level, loss of synchronization, loss of bit count integrity, reframe errors, etc. and is related to probable areas within the hardware environment. This in turn initiates the procedures for fault isolation and determination of the type of corrective action required.

Fault Isolation (F/I). Fault isolation is the manually conducted investigation (measurement and/or test) of specific areas of equipment. Depending on the type of degradation, and the results of the measurements and tests it may result in either preventive maintenance (calibration tweaking, increase of cooling by cleaning fans and filters, burnishing of relay/switch contacts, etc.) or corrective

maintenance which requires the replacement of components or subassemblies. It should be noted that preventive maintenance measures (PMM) will normally be initiated as a result of PMA and will be performed in sufficient time to prevent equipment outages or loss of traffic.

One other area which must be considered in overall evaluation of system performance assessment are Site Alarms (S/A). Since S/A is not a measure of performance, no ranking can be assigned to these alarms. Each must be evaluated individually, as they may occur, for the implication of hazard to or interference with the operating system. For example, a fire alarm or illegal entry alarm would require the immediate dispatch of fire fighting or security personnel to the site as required, whereas a power failure alarm would not require such immediate attention if the site was equipped with an automatic cut-over emergency power generator and no loss of signal was observed. The fact that signal loss did not occur would be prima facie evidence that the emergency generator was functioning properly.

2.3.1.5 Digital Versus Analog Duality

Figure 2-9 provides reference block diagrams for illustrating performance assessment duality as applied to analog transmission equipments versus digital transmission equipment. Analog equipment performance may be verified by measuring input signal quality and comparing this with output signal quality. This is noted in the top portion of the figure. Digital transmission equipment performance, on the other hand is not verifiable by any measure of input/output signal analog characteristics. This statement is equivalent to noting that satisfactory analog signal voltage/time structure does not indicate that the information data stream is error free. In fact, the only way that the throughput error rate performance of a digital equipment can be verified is to make a measurement directly or, perhaps presumptively, related to the error rate performance itself. No measurement of the analog quality of a digital stream can verify its integrity. This obvious observation is the key to recognizing digital PA. Digital signals are information streams, a digital equipment is performing satisfactorily only when it is operating according to design algorithms on the information data stream.

Hence, while it is appropriate to measure signal quality in/out for PA measurements associated with analog equipment, the functional parallel or dual measurement for digital equipment is error rate (or some other measure of digital algorithm malfunction).

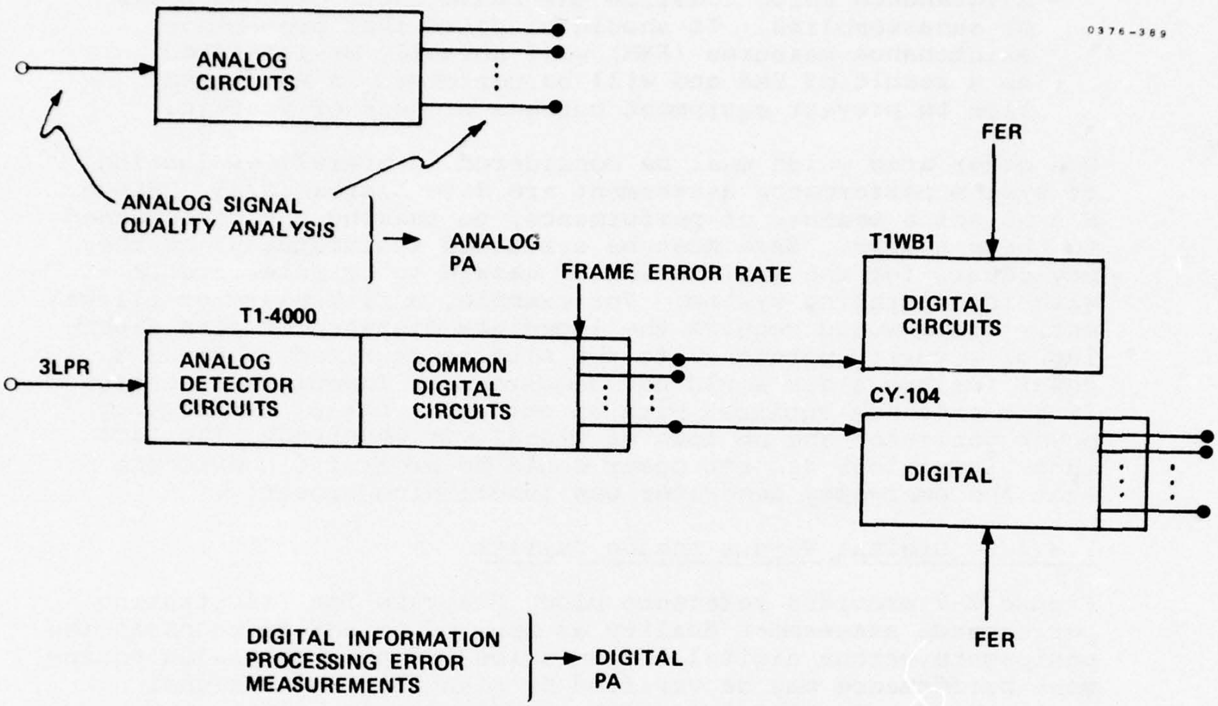


FIGURE 2-9. PERFORMANCE ASSESSMENT DUALITY

Furthermore, while an error rate measurement characterizes the performance assessment state of a digital equipment it is not relatable to "performance margin" in the usual sense that has become associated with margin. Referring again to Figure 2-9 where the T1-4000 is represented, the analog circuits, I/O, where the T1-4000 joins the analog FM radio system can have "performance margin" associated with them. However, the digital portion of the multiplex units are not realistically characterizable by a margin. A degraded multiplex adds to error rate, but error rate is a performance assessment parameter, not a measure of margin.

To amplify the contrast, the analog portion of the T1-4000 may degrade considerably before performance (error rate) is affected. Such degradation in advance of an adverse affect on performance is performance margin degradation.

As long as RSL is high, radio noise low, and baseband signal quality high, the input detector circuits of the T1-4000 may degrade without affecting error rate. However, if radio noise is degraded or an RSL fade occurs (which it will) the degradation in margin will express itself in an unwarranted error rate increase.

Most usually, discussions of performance margin which have occurred are relatable to the degree of analog signal quality degradation which can occur without significantly affecting error rate.

The measurement of FER in the T1-4000 verifies satisfactory operation of the radio system and the common portions of the T1-4000. Those circuits associated with individual submux ports, however, are not verified by T1-4000 FER. Note in examining Figure 2-9, however, that CY-104 or T1WB1 FER verifies the associated T1-4000 subchannel.

This observation leads to the generically true statement that FER primarily verifies satisfactory operation of the next level up in the equipment hierarchy, as well as the common circuits associated with the framing.

It is concluded that a form of duality applies in comparing the role of analog versus digital equipment performance assessment measurements and that error rate (presumptively deducible from FER) is an effective measure of digital equipment performance (but not margin), since bit errors are just as likely to occur in the framing bit as in any other bit in the frame (assuming a near random bit stream). (Refer to Volume I, Paragraph 2.2.4.1).

The FER measurement on the T1-4000 data stream bears some resemblance to measuring pilot tone parameters in an analog multiplex. Framing bit errors in excess of a predetermined threshold are flags of degraded or undesirable operation. The T1-4000 data stream operates at approximately 12.6 megabits per second (Mb/s). One in every 130 bits is a framing bit. The framing bits are an alternate 0, 1 pattern at approximately 100,000 bits per second (b/s). The frame bits may be considered to be an embedded test pattern in the primary data stream. Thus, measurement of FER is a convenient method for implementing a measure of framing bit errors.

Submux FER is likewise a desirable parameter; however, CY-104 framing bit errors are not realistically accessible, nor is any comparable parameter, therefore, no measure of CY-104 error rate is available.

CY-104 performance may be verified in-service by measuring analog output VF channel parameters when appropriate signals are present. Appropriate signals are supervisory tones, test tones, and idle terminations.

VF channel measurements are required for complete assessment of the CY-104 operation in any case; however, numerous VF measurements are cumbersome and costly. Thus CY-104 performance is effectively assessed by optional monitoring of a VF channel from each of the two subgroups, of 12 channels each, in the unit. FER would be a very useful measurement for assessing CY-104 and T1-4000 subchannel performance if it were available on the CY-104, in its absence, no fully equivalent substitute is available. Therefore, VF channel monitoring must be used to verify the CY-104.

While considerable discussion has revolved around PA and PMA measurement for digital and analog equipment, there is also a role for sudden service failure alarms. This role is discussed in subsequent sections.

2.3.2 Monitoring Approach

For the purposes of this discussion, approaches to monitoring a communication system typified by the FKV are categorized as Top Down, Bottom Up, and Omnistratametric. These categoric approaches may be applied to performance assessment and margin measurements, alarm gathering, fault detection and isolation considerations, maintenance approach, operational manning, and

degradation detection and isolation.

The communication system may be viewed as a layered media with the radio system and path constituting the highest layer and VF/DC drop and inserts constituting the lowest layer. Intermediate layers are made up of the T1-4000 high level multiplex and the CY-104/T1WB1 submultiplexer. Figure 2-10 illustrates these layers.

2.3.2.1 Top Down

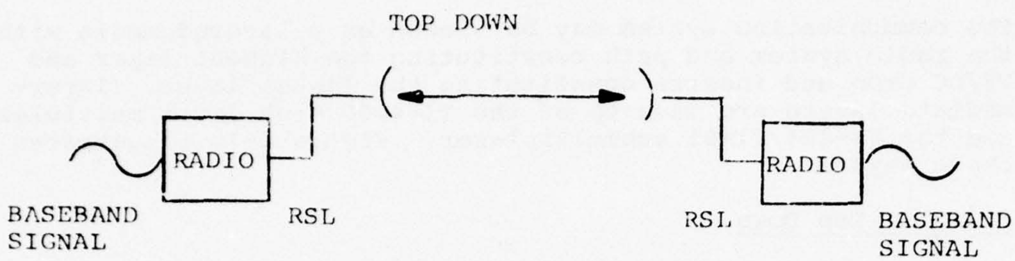
Figure 2-10 illustrates an elevation drawing approach to representing the communications system strata for a portion of the FKV system. The top down approach to monitoring the FKV places top priority on monitoring the top most layer composed of the radio baseband I/O, the radio system, and the link path. This stratum (or layer) is amenable to conventional automated monitoring. Included would be: RSL, baseband noise measurements, and baseband signal quality measurements. These measurements may be employed to produce measures of performance margin, performance assessment, trend analysis, and fault isolation for the radio system (and paths) throughout the FKV.

A monitoring system which included no other measurements except these and certain ancilliary ones would be of great operational benefit in tech controlling and maintaining the FKV.

Degradations are commonly conceptually handed-off to the radio system, this practice may be even more prevalent in the FKV in view of advance publicity which augurs for a trouble-free multiplex system with an occasional exception for an infrequent sudden hard failure, detected by an alarm, but especially not including intermittent bit flap or other, possibly subtle, modes of multiplex degradation.

A Top Down system featuring exacting PA measurements will not permit handing off multiplex problems to the radio system. Also, such a system will detect degradations in the radio system when they occur and some degradations may be anticipated before they become serious. Such a Top Down system would go a long way toward simplifying the life of an FKV technical controller and toward vectoring radio system preventive maintenance action in a structured effective manner.

A disadvantage of the Top Down approach is that not all equipment strata are monitored with equal emphasis. For example, more monitoring capability is applied to the radio system than to the T1-4000 multiplexer level of the FKV. Additionally, the monitoring system is not oriented to monitoring link or circuit



ADVANTAGES:

- PERFORMANCE ASSESSMENT
- PERFORMANCE MARGIN
- TREND ANALYSIS
- FAULT ISOLATION TO RADIO SYSTEM

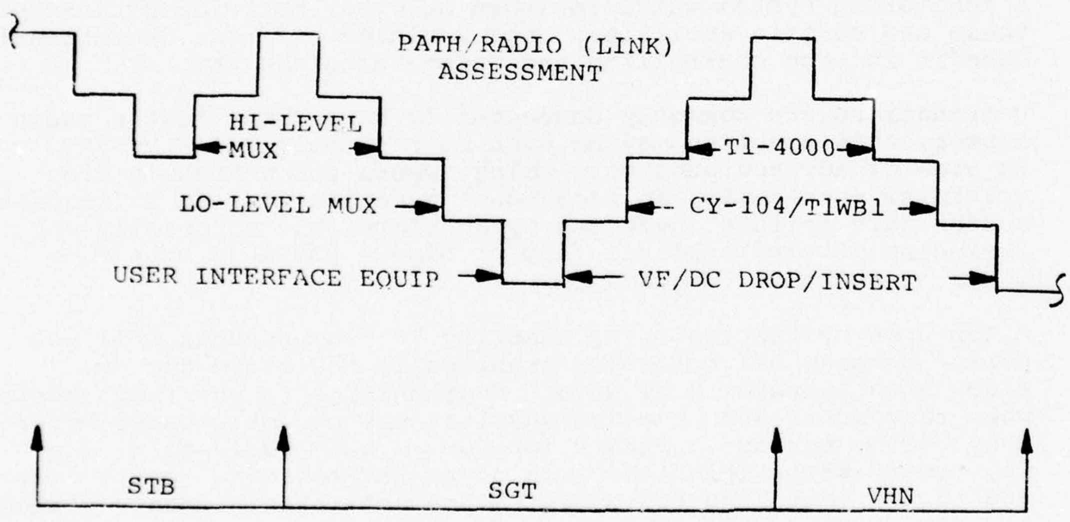


FIGURE 2-10. COMMUNICATIONS SYSTEM STRATA

status and as a result it is difficult to trace down the origin of link or circuit problems.

2.3.2.2 Bottom Up

The Bottom Up approach to monitoring a transmission system is portrayed, in part, by Figure 2-11.

The Bottom Up approach takes advantage of the tree structure of VF channels and channel groups. Figure 2-11 illustrates a possible tree structure for VF channels/groups riding the transmission system pipes from the VF drop points at A, B, C, D, and E to the bottom reference site. The numbered nodes 1 through 8 are relay points where the channels from A to E do not drop to VF.

The channels/groups from the VF drop sites A to E are labeled according to the site they come from at the reference site.

Bottom Up transmission system supervision is accomplished by scanning the VF channels/groups from A to E at the reference site. Straightforward analysis then provides a form of performance assessment and fault isolation. If all VF channels at the reference site are assessed as satisfactory, then performance is satisfactory on all transmission system pipes shown in the figure (in the direction of transmission toward the reference site). On the other hand, if a fault (degraded performance) is detected on a particular subset of (lettered) channel/groups received at the reference site, then the fault can be presumed to be limited to only those transmission pipes which are common to the degraded subset.

For example, if degradation is detected on the channel/groups from site-C only, then the degradation can be isolated to the pipes from site-C to site-8. Similarly, if degradation is detected on the channels/groups from both B and C in Figure 2-11, then the degradation can be isolated to the pipe from 8 to 6. Note, however, that relay site 5 lies between 8 and 6 and that the source of degradation cannot be isolated to either individual pipe segment from 8 to 5 or 5 to 6, but only to the composite from 8 to 6. Thus we have exposed a basic undesirable feature of the bottom up approach to transmission system supervision, namely the inability to determine the precise link/pipe which is degraded. Also it must be noted that unless comparable VF measurement equipments are located at A, B, C, D and E, there can be no assessment of link/pipe performance in the direction away from the reference site.

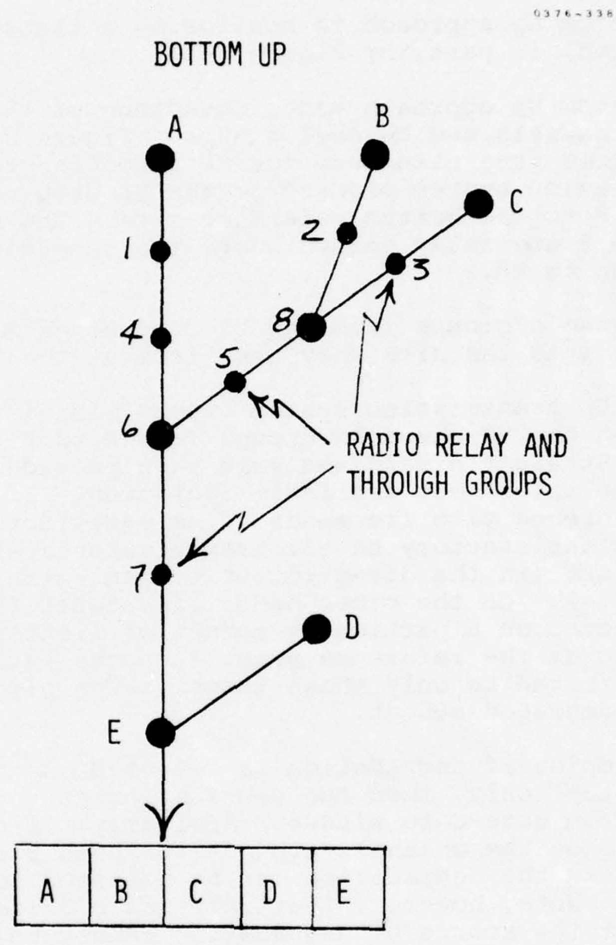


FIGURE 2-11. TREE STRUCTURE OF CHANNELS FROM DISTANT VF BREAKOUTS INDICATES SYSTEM QUALITY

The Bottom Up approach to system assessment and fault isolation is superior to no approach at all, but it does not compare favorably with the Top Down approach which is specifically concentrated on PA measurements and fault isolation analysis for the top stratum (the radio system).

2.3.2.3 Sudden Service Failure Sensing System (SSFSS)

In the course of evaluating the best approach toward assessment monitoring of the FKV system it was recognized that a need existed for an immediate and positive alarm in the event of a catastrophic failure; in a link, at a site and/or of equipment. To this end the concept of SSFSS was developed. SSFSS uses an alarm display which selectively furnishes status of the top levels of the transmission system. The concept is discussed in detail in Volume I, Paragraph 3.9.1 and the subparagraphs thereof.

2.3.2.4 Omnistratametric

Ominstratametric is a nonce word referring to performance measurements made at all levels of the communication transmission system.

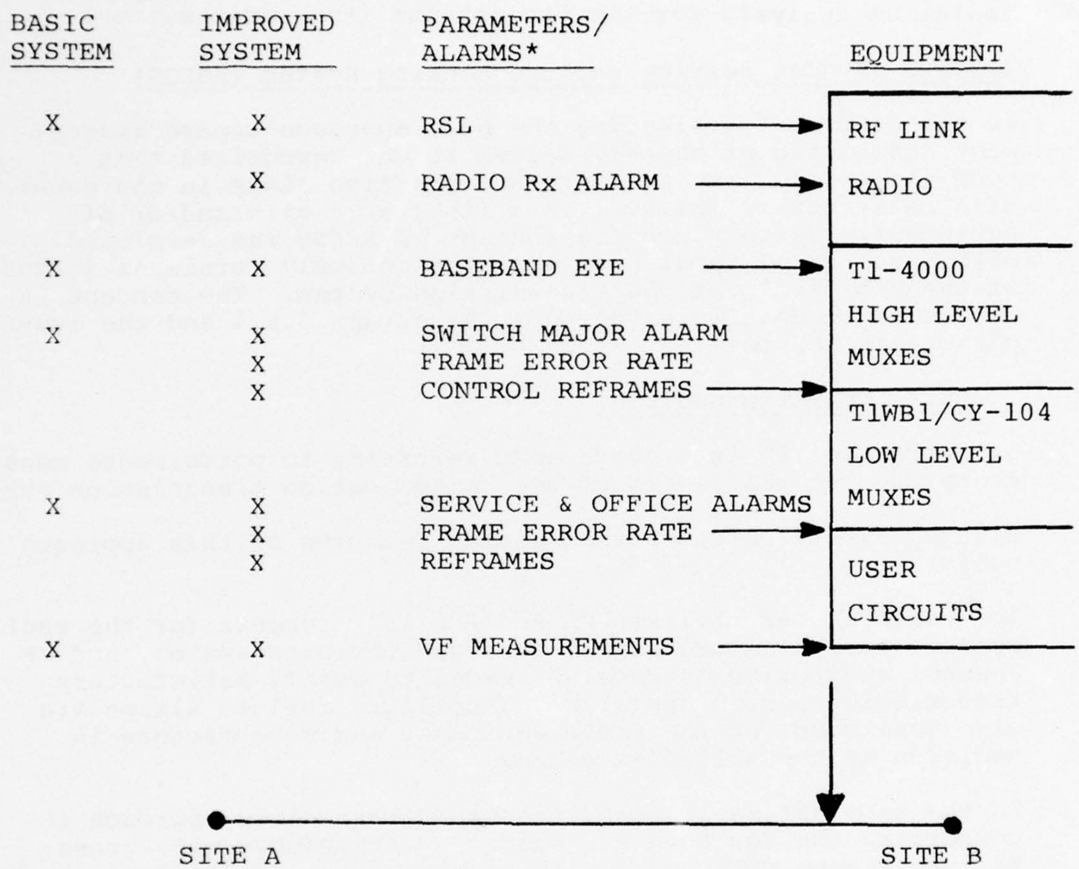
Figure 2-12 illustrates the leading features of this approach in overview.

The basic system utilizes PA and PMA measurements for the radio system, gross failure alarms for the multiplex system, and VF channel monitoring on received sides to verify satisfactory transmission system operation. Ancillary failure alarms are also monitored for the radio equipment and site factors in addition to the multiplex alarms.

In the simplest basic form, the Omnistratametric approach incorporates the Top Down and Bottom Up approaches with gross failure alarms detected for the intermediate (multiplex) strata.

As additional resources become available, the first allocation priority is assigned to PA measurements for the highest level multiplex, the T1-4000 and then for the lower level multiplexes, CY-104 and T1WB1 and finally to a gross failure alarm to the radio. The column labeled Improved System represents the fully progressed Omnistratametric approach.

Assuming that the desire to withdraw manpower from the FKV is to be fulfilled, it will be necessary to establish a fully progressed Omnistratametric monitoring system. This system will cost something notable in the space/money budget allocated to the site;



*Parameters and alarms are defined in Volume I, Table 4-1.

FIGURE 2-12. PROGRESSIVE OMNISTRATAMETRIC

however, this in itself is not seriously deleterious because there is no way to withdraw manpower without furnishing an electronic replacement. The electronic replacement for a man is not likely to be trivial in cost; however, the cost savings in the withdrawal of a man are not trivial either.

The Omnistratametric approach provides an organized, step-by-step, layer-by-layer assessment of the communication system.

Philosophically speaking then, the Omnistratametric approach, fully progressed, is the recommended approach to FKV monitoring requirements.

It should be noted that much of the discussion of selection of the philosophical approach to monitoring system design is straightforwardly extendable to any portion of the DCS independent of the multiplex and radio type (analog or digital).

2.4 NODAL CONTROL CONCEPT

Nodal control is the coordination, supervision, and management of the operation and maintenance of a portion of the DCS from a central site.

2.4.1 FKV Communication System Control Concept Development

In developing a control concept for the FKV communications system and the performance monitoring system a possible hierarchy of control is postulated in the following paragraphs. It should be emphasized that both the hierarchical structure and the methodology are concepts only and are not intended to convey any detailed or explicit methods of technique or procedure. The only intent is to demonstrate the capabilities, inherent in the assessment system, toward reduced manning with increased equipment and circuit efficiency, with full scale implementation of the assessment system. Figure 2-13 illustrates the hierarchical structure as visualized for the FKV.

2.4.1.1 Communication System Control Hierarchy

The Communication Equipment Site (CES) is the lowest level in the hierarchy. These sites include IF/baseband relay sites as well as manned technical control facilities which do not exercise nodal control. In the future evolving DCS, the CESs will largely be unmanned. The ATEC equipments ordinarily located at a CES consist of Alarm Scanners, Measurement Acquisition Controllers, and option sensors such as Baseband Monitors and Analog Scanners.

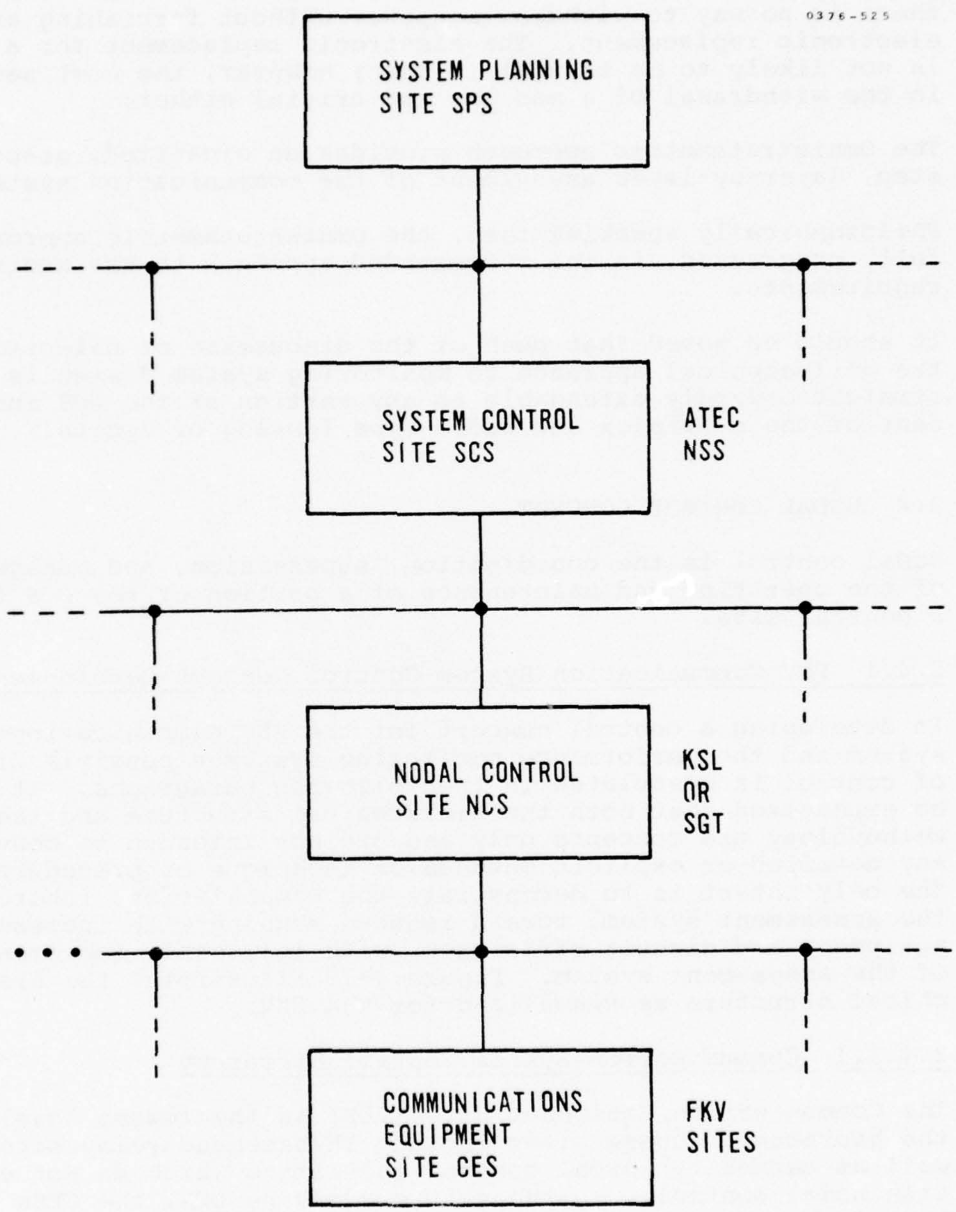


FIGURE 2-13. VISUALIZATION OF TECHNICAL CONTROL AND COMMUNICATION SITE HIERARCHY USED IN STUDYING ATEC ADAPTATION TO THE FKV

The Nodal Control Site (NCS) is a manned site responsible for the operation of its host site and a contiguous portion of the DCS composed of CESs. The six sites of the FKV are appropriately controlled from a single NCS. The ATEC equipments ordinarily located at a NCS consists of the equipment at a CES plus a processing element, typically PATE (Programmable ATEC Terminal Element), as well as Alarm Displays, a Master Alarm Display, and a CRT/Printer output terminal. Information from the CES's is gathered by the PATE for use in the decision making processes of the NCS supervisory personnel.

The System Control Site (SCS) is a manned technical control operation site responsible for coordinating and supervising the operation of several NCSs covering a logical geographically related command structure. The ATEC equipments ordinarily associated with the SCS system control function is NSS (Nucleus Subsystem) composed of a central processor element, computer peripherals, and display elements. The SCS communicates directly with the NCS PATEs and in no case concerns itself with making or interpreting measurements at a CES. An SCS is a regional operating control facility,

The System Planning Site (SPS) coordinates and supervises SCSs. The SPSs only occasionally participate in making moment-to-moment operating decisions. The main SPS emphasis is in planning improved circuit assignments by user and route location. The SPS communicates with reporting SCSs and never participates in making/interpreting measurements. Here again the ATEC equipments ordinarily associated with the SPS is an appropriate version of an ATEC NSS.

Since this Digital ATEC Adaptation Study is confined to CES and NCS applicability the role of SCS and SPS will not be discussed any further.

2.4.1.2 Reporting Concept

Assessment monitoring equipment installed at the CES's will output their collected status data to the NCS each time they are polled by the PATE. Polling can be accomplished as an automatic repetitive routine under PATE program control or can be manually accomplished, when necessary, by instructions from the tech controller through the PATE control terminal. In either case, the reports can be accumulated on printed pages or magnetic (cassette) tapes for management analysis purposes by the NCS tech controllers and maintenance managers. In the initial

stages of nodal control automation, reports can be prepared manually as they are today. Present formats can be altered to ease the preparation of the reports from the stored displays (with operator entered notations).

In the later phases of expansion to automated nodal control operation, manual preparation of reports on transmission system problems can be reduced. Automated access to the displays will permit passing information up the command/control chain without overt nodal control operator action.

2.4.1.3 Operational Manning

Manning within the FKV will probably consist of three categories: (1) maintenance personnel, (2) technical controllers responsible for supervision of user drops and servicing the user interfaces, and (3) technical controllers responsible for transmission system supervision.

Maintenance concepts are addressed in the next paragraph.

User service supervision is most likely the historic basis for tech control. Although tech control now encompasses a much broader scope than just user interface supervision and servicing, user service supervision is still presently viewed as the key ingredient to be used relative to its evaluation. User service supervision requirements in the FKV are not notably different than for any other system of comparable size. Unless an automated replacement for the tech control patch panels (autopatch) is contemplated (a costly thought) men will always be required to reroute VF/DC user circuits. Therefore, the basic requirement for tech control manning is to service user drops and its magnitude is proportional to the number of such drops that are serviced/supervised at a given facility.

On the other hand, transmission system supervision may be executed from one control site, the nodal control as described in Paragraph 2.4.1.1. Logical possible choices are Stuttgart and Koenigstuhl. Both have substantial numbers of Digroup VF breakouts and both are geographically within practical distances for the dispatch of maintenance personnel to unmanned sites, if necessary. Figure 2-14 illustrates the VF breakouts for the FKV.

The presence of substantial numbers of VF breakouts suggest that operational manning will be required at both sites at all times. It is efficient to consolidate the nodal control transmission system supervision function by locating nodal control at a site

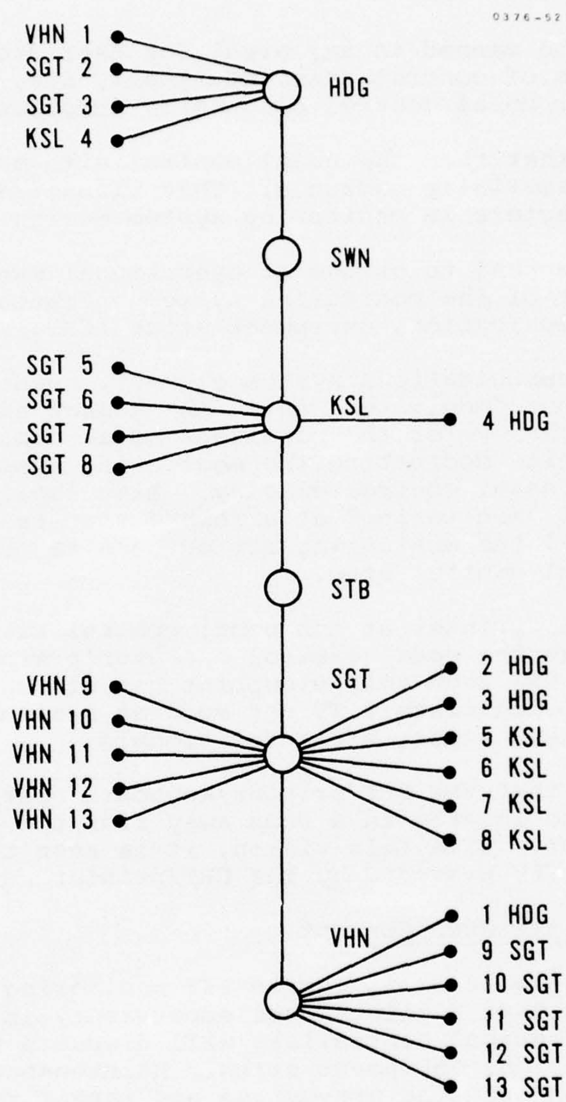


FIGURE 2-14. VF DIGROUP BREAKOUTS IN THE FKV

which must be manned in any event for user drop supervision. For purposes of concreteness, Stuttgart, SGT, is arbitrarily selected for nodal control discussion purposes.

The sites other than the nodal control site have been visualized as being essentially unmanned. This visualization imposes the following factors in monitoring system design:

1. No appeal to or use of operational manning can be a part of the monitoring system operational concept for communications equipment sites (CESs).

2. A communications system element, event, trend, etc. is not "monitored" until the sensed aspect is reported to the eye of the cognizant nodal controller. This implies dedicating the monitoring system to driving the nodal control display. Also implied is the thought that "monitoring" at a remote site is not completed until the monitoring act outcome is telemetered to the nodal control site.

3. A CRT/printer at the nodal control site may be thought of as the nodal control operator's window into the FKV. The CRT from this viewpoint has elements of analogy to a closed circuit TV set such as a security guard uses to scan remote areas for trouble.

It is noted that the CRT/printer/keyboard operator interface unit could be located in a room away from the nodal technical control floor. With this vision, it is seen that the operational view of the FKV provided by the CRT/printer must be comprehensive.

2.4.1.4 Maintenance Concept

For the purpose of designing an FKV monitoring system, it has been assumed that a maintenance supervisor, in cooperation with the nodal technical controller, will dispatch maintenance teams to communications equipment sites. Maintenance teams would be dispatched for routine preventive and repair maintenance. It has been assumed that, typically, communications system service is furnished by standby equipment when an "A"(normal on-line) unit is failed or seriously degraded.

In the operation of the FKV, degraded service will occur when the "A" unit is degraded, but not sufficiently to cause a switch to the "B"(standby) unit.

Monitoring system controlled switching between alternate units would also potentially contribute to degradation isolation and

would forestall operation with degraded primary equipment when the alternate was not degraded.

ATEC equipment could sense degradation in unit "A" or "B" and cause a switch from one unit to another if such switching action were permitted in the FKV, however, such switch action cannot be controlled externally for the communications equipment because the communications equipment is not designed for externally controlled switching. As can be seen the monitored system requirement is to identify failed or degraded equipment for maintenance action. It is not the intent of the monitoring system to go beyond the equipment level to the card level in fault isolation. Determination of difficulty with an equipment is a task left to the maintenance team.

2.4.2 FKV Nodal Control Site Considerations

The requirement to reduce the FKV operator and maintenance (O&M) personnel was the primary ingredient that led to a Nodal Control approach. The secondary consideration was more efficient use of the remaining O&M personnel. For while tech control personnel are required at VF/DC drop sites to service and alt-route such circuits, they are required at the NCS only for the purpose of supervising the communications transmission system. Therefore, it is well to note that the nodal control approach to monitoring FKV arises not from its digital nature, but from motives of manpower savings and efficiency. Hence, the general approach to nodal control is applicable to any transmission system regardless of the nature (digital versus analog) of the multiplex and/or radio equipments.

The need to devise new adaptation sensors for new types of transmission equipments will continue to arise, of course, as transmission equipments continue to evolve. These adaptations; however, need not produce any fundamental changes in the monitoring system concept of nodal control.

Inasmuch as manpower has been withdrawn from the non-nodal sites (the communication equipment sites), trained manpower can be allocated to the nodal control site. At this site, the primary consumer of monitoring system information (displays) is the nodal control supervisor responsible for the supervision of the FKV transmission system.

The nodal control supervisor initiates control action in response to transmission system service failures and degradation. Another key consumer of monitoring system displays/information is the maintenance supervisor. In addition to directing corrective

maintenance actions, he will be able to assess communications equipment degradation before it offers a significant impairment to satisfactory transmission system performance.

2.4.3 Monitoring System Users

The supervisors are highly motivated trained operators of the monitoring system. In contrast there is another important system user, the "untrained operator". The untrained operator is one who has not had the benefit of a training course in the operation of the monitoring system and/or in the operation of all of the elements of the communication system. The untrained operator is important because many, if not most, operators will be untrained. Not only will some operational site personnel fall into the untrained category, but managerial personnel, as well as evaluation test team members, may not have an opportunity for full training before attempting to use the monitoring system.

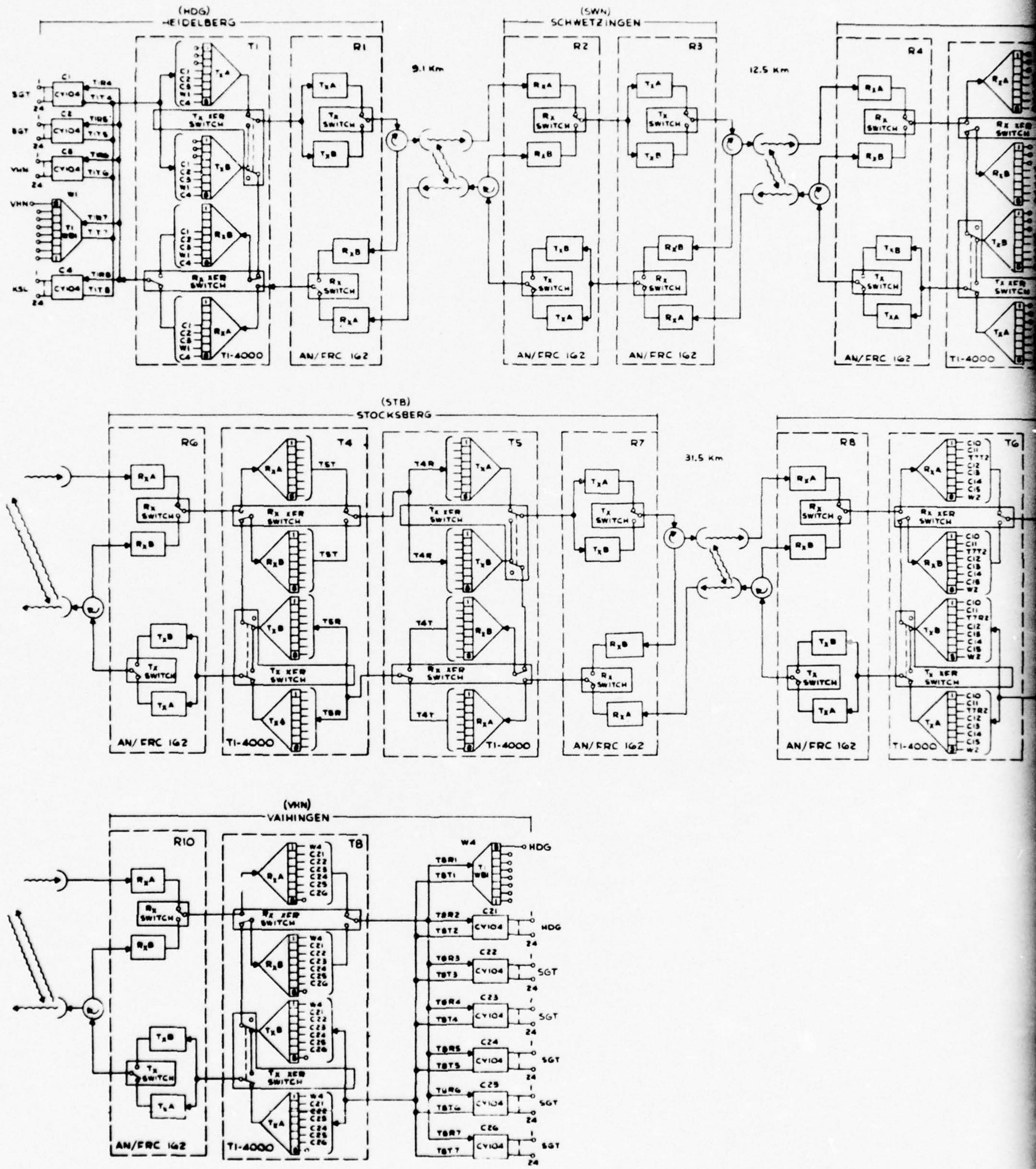
The design of the display system addresses three types of users, the highly skilled and motivated technical controllers, maintenance supervisors, and the broad class of untrained operators.

2.4.4 Monitoring System Operator Interfaces

Control rooms for pipeline systems, power distribution grids, petroleum refineries, and railroad switching yards feature highly readable diagrammatic displays. A comparable approach can be visualized for the FKV. Reference to Figure 2-15, the FKV System Diagram, suggests that if this diagram were enlarged to a suitable desk-top size that status lights could be mounted within or near the symbol for each equipment function with the FKV system. These status lights, three for each equipment, colored Red/Amber/Green could be illuminated by the monitoring system to indicate the status of each equipment (and radio path).

Any operator viewing a display of this type would easily gain an appreciation of the status of the equipments without formal training. A display type related to this approach appeared in the original ATEC study of January 1970; however, the Diagram Display, as it was called, was eventually eliminated from the ATEC system development during the design review process.

The approach generally used in modern monitoring systems, employs appropriately formatted CRT displays. CRT displays are very flexible and can be very effectively driven by a computer. The CRT displays which have been designed for the present nodal control application provide information for all three display



(HDG)
HEIDELBERG
(SWN)
SCHWETZINGEN
9.1 Km
12.5 Km
T1
R1
R2
R3
R4
TI-4000
AN/FRC 162
SGT
VHN
KSL
CY104
(STB)
STOCKSBERG
R6
T4
T5
R7
R8
T6
31.5 Km
(VHN)
VAIHINGEN
R10
T8
W4
HDG
C21
C22
C23
C24
C25
C26

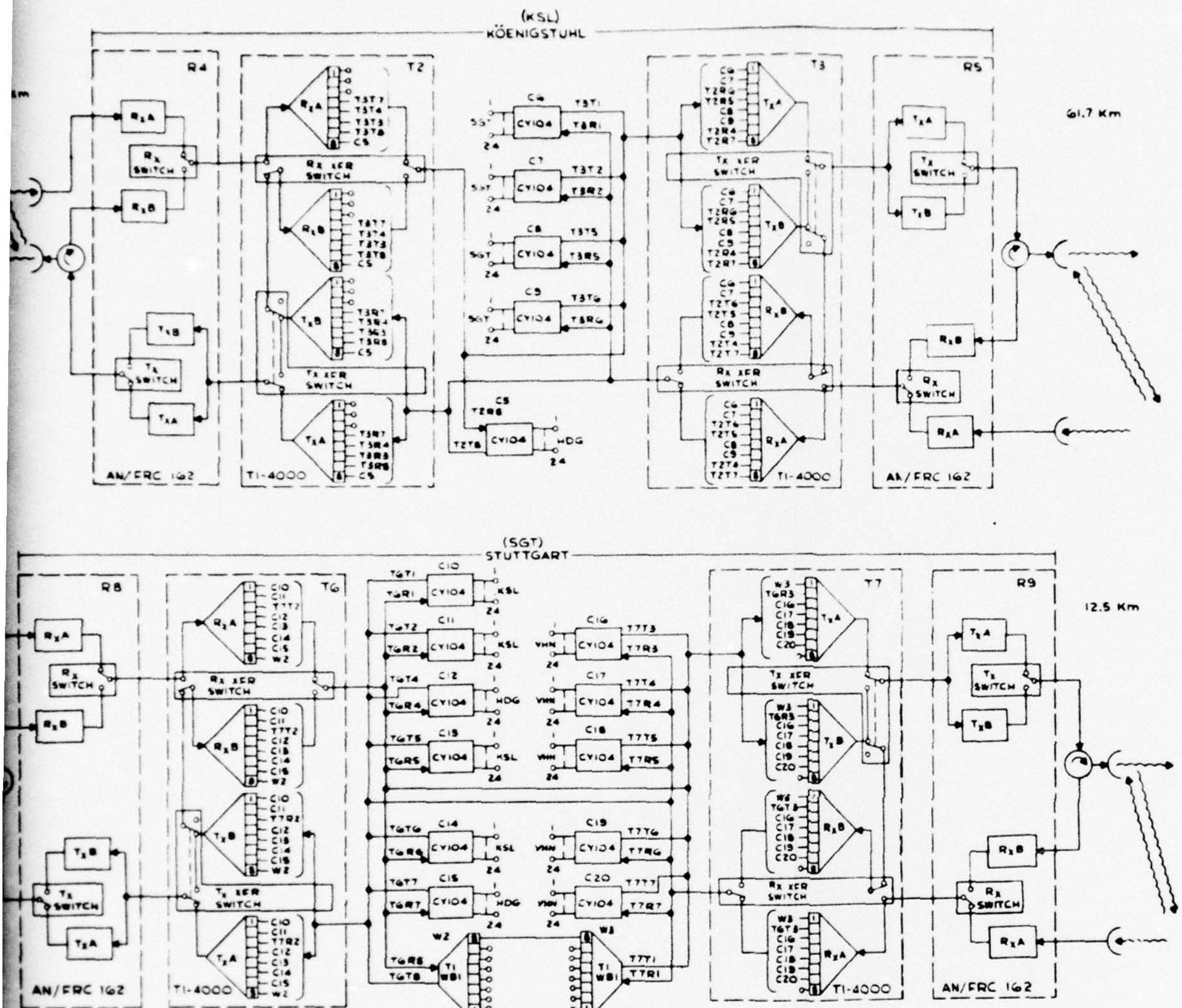


FIGURE 2-15. FKV SYSTEM DIAGRAM

user types (see Volume II, Paragraph 3.4, for a detailed discussion of the CRT outputs). However, a CRT can display only one page at a time and it is possible to be in the process of examining a degradation/trend at one site with the CRT and simultaneously have occur a major alarm at another site which should receive immediate attention. This suggests that an alarm system operating independently of the CRT should be considered.

Utilizing the existing ATEC Alarm Scanner (AS), Alarm Display (AD), and Master Alarm Display (MAD), such an alarm system can be synthesized. Properly designed, the alarm display system will overcome the problems of:

1. Alarm cascade

2. Over alarming - drawing operator attention to routine occurrences unworthy of his attention

3. Relation of alarm light indicators to specific troubles

SSFSS is presented in Volume I, Paragraph 3.9.1, FKV System Alarm simulation. The Sudden Service Failure Sensing System (SSFSS) provides a constantly updated display of significant major alarms, keyed to the FKV System Diagram of Figure 2-15 at the nodal control site.

These significant major alarms represent disasters which must receive immediate control attention. Reference to a typical SSFSS display in Figure 2-16 clarifies this point. Failure of both radio receivers, for example, in R6 constitutes a service failure and the alarm designated as R6RX will be illuminated within 4 seconds at the nodal control display. The other service failure indicators operate similarly. The alarm indicator marked SITE corresponds to intrusion, fire, flood or other site related problems requiring immediate action. Note that a routine site problem such as a tower light failure is picked up and displayed as a CRT display item and brought to the operator's attention at a slower pace. Likewise, failure of a prime equipment such as T4RXA (Figure 2-16) does not constitute a service failure providing the Standby unit will not cause the SSFSS alarm to illuminate, but this information will be displayed on the CRT.

The SSFSS display for the six sites of the FKV are racked together near the CRT for operator viewing. The diagram for each site appears above the alarm display for each site. These site drawings are abstracted from the FKV System Diagram of Figure 2-15. Thus the SSFSS display furnishes a constant view of the transmission system and focuses operator attention toward a system viewpoint.

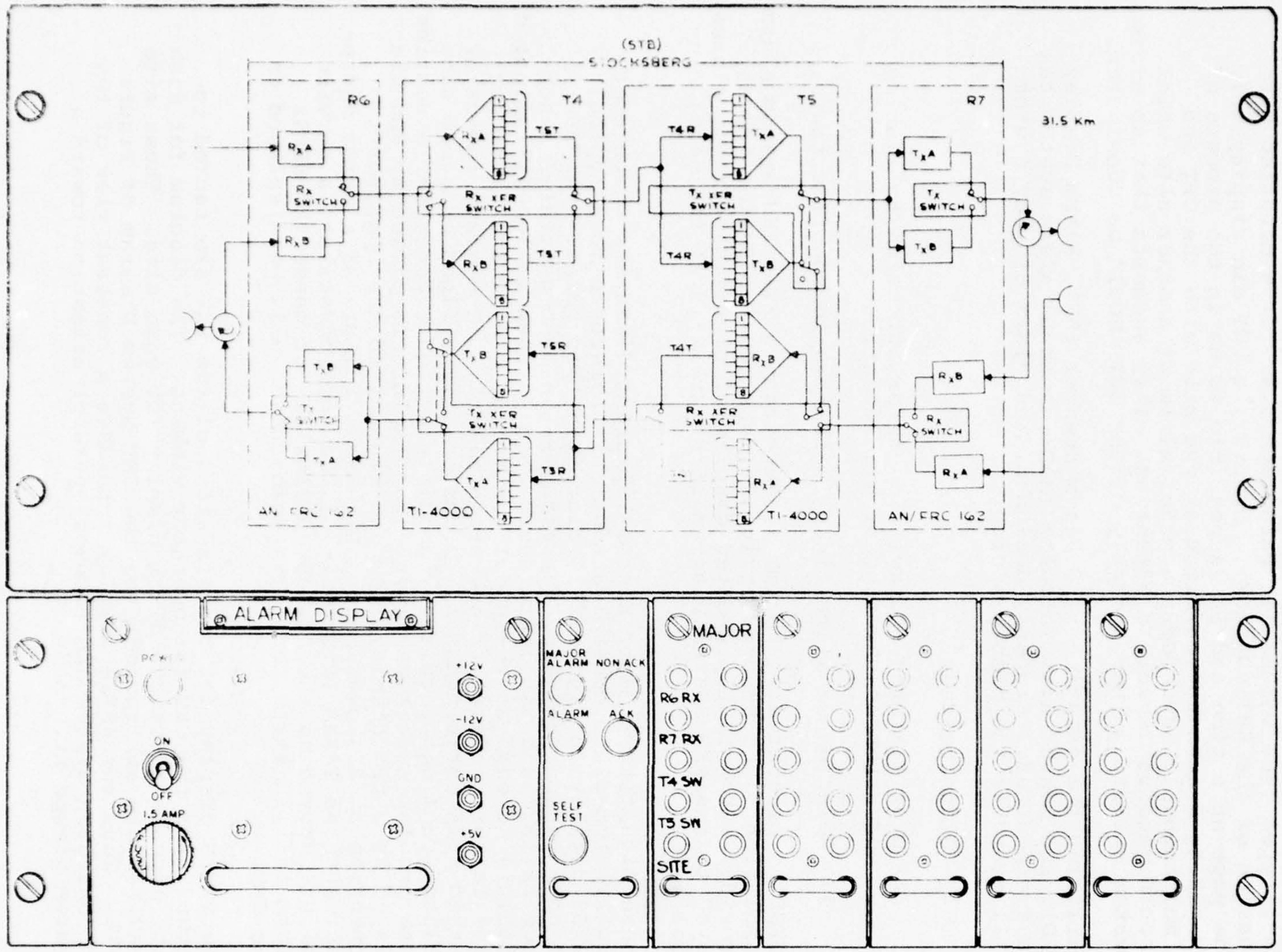


FIGURE 2-16. SSFSS DISPLAY FOR STB

Alarm isolation relative to the SSFSS display is readily accomplished by the operator viewing the display for the highest level of SSFSS alarm after the alarms have cascaded and have reached the "alarms of repose" state. The highest level (level in the sense of strata in the transmission system) alarm is the causative alarm for the SSFSS display of the alarms of repose. Several examples of the repose alarms have been simulated and it has been verified that alarm cascade is not a confusion factor in utilizing the SSFSS.

2.5 SUMMARY

The preceding paragraphs within this section have introduced the FKV digital system configuration and discussed system level requirements and salient performance assessment parameters.

Considerations and requirements for fault detection and isolation, performance assessment and degradation isolation and performance margin assessment of a digital communication system have been defined.

Basic monitoring system concepts have been advanced and the inherent advantages of a nodal control monitor system approach have been described.

Within this conceptual framework emphasis is now shifted toward the individual elements comprising the FKV system - the communications equipments employed.

Section 3 addresses each of the FKV equipment types and reports the results of alarm and parameter selections compatible with the established PA/FI/TA guidelines.

Section 3

FKV EQUIPMENT STUDY

3.1 INTRODUCTION

An in-depth study and analysis was performed on the FKV equipment, listed in Table 3-1, for the purpose of identifying equipment monitor points which could contribute to PA/FI/TA of the FKV digital transmission system. The equipment study and analysis was performed independently of the constraints of a monitoring system approach, except in the most general terms, thereby enabling an unbiased selection of candidate monitor points for the FKV equipment. The CY-104, PCM multiplexer, was studied in less detail because of TEMPEST requirements which prevent the addition of new monitor points to the equipment. However, existing alarms and indicators were considered.

An initial monitor point tabulation was thus developed for each of the FKV equipments. Trade-offs were next undertaken and a reduction of the initial Candidate Monitor Point List was made using the system analysis tool of a selection matrix. Ratings were assigned each monitor point in the categories of usefulness, availability, and processing required. This technique ultimately determined the degree of "goodness" of each monitor point. These goodness values provided a quantitative means of relative comparison of the candidate monitor points. Weighting factors were established and a cut-off value of goodness was set as is described in Paragraph 3.6.

The resultant selections-- The Preliminary Recommended Monitor Point List-- were then evaluated from a total monitor system standpoint. Rationale was established whereby final selection or rejection of these candidates for use in the FKV monitoring system could be made.

Ultimate monitor point selections are discussed in Paragraph 3.7--Recommended Monitor Points and in Paragraph 3.8, Rejected Monitor Points.

TABLE 3-1. FKV EQUIPMENT

Nomenclature	Description
AN/FRC-162(V)	FM Microwave Radio
T1-4000	Asynchronous TDM Multiplexer
T1WB1	Asynchronous 50 Kb/s Multiplexer
CY-104	PCM Channel Bank

3.2 CY-104 PCM/TDM

3.2.1 CY-104 Description

The CY-104 provides the capability for the multiplexing of 24, 4-wire telephone trunks into a 1.544 megabit per second (T1) encrypted binary bit stream. This function is implemented using three equipments housed within the same enclosure: HY-12 channel bank, HN-74 interface unit, and KG-34 key generator.

The HY-12 encodes the voice frequency channels into the D2 format. The KG-34 provides the encrypting function. The HN-74 interfaces control signals between the HY-12 and KG-34 and provides the external interface.

Each of these three equipments is packaged in a TEMPEST-type cabinet which means that the signals available for performance monitoring and assessment are restricted. The TEMPEST design imposes the constraint that every signal exiting the device must be properly filtered and conditioned. Thus, unless alarm signals have been included in the TEMPEST design, they are not readily available for use in performance monitoring.

The VICOM D2 channel bank is the main subsection of the CY-104. For functional understanding purposes, the D2 will be introduced here. More detailed data is included as Appendix A2-1 and discussions of the nonlinear PCM coding-decoding technique may be found in Volume II, Appendix B.

The VICOM D2 channel bank time division multiplexes and pulse code modulates 24 VF signals (including signaling) into a single 1.544 Mb/s bipolar pulse stream. This pulse stream is then transmitted to a far-end terminal where the reverse operation is performed; that is, the signal is demultiplexed and converted back to the original set of VF signals and signaling. The terminal is full duplex; that is, each terminal contains both a transmit and receive capability.

The following sequence of operations are performed by the transmit section of the D2 (Block Diagram, Figure 3-1):

- VF and signaling conditioning
- Time division multiplexing
- Nonlinear PCM encoding
- Frame organizing
- Bipolar conversion.

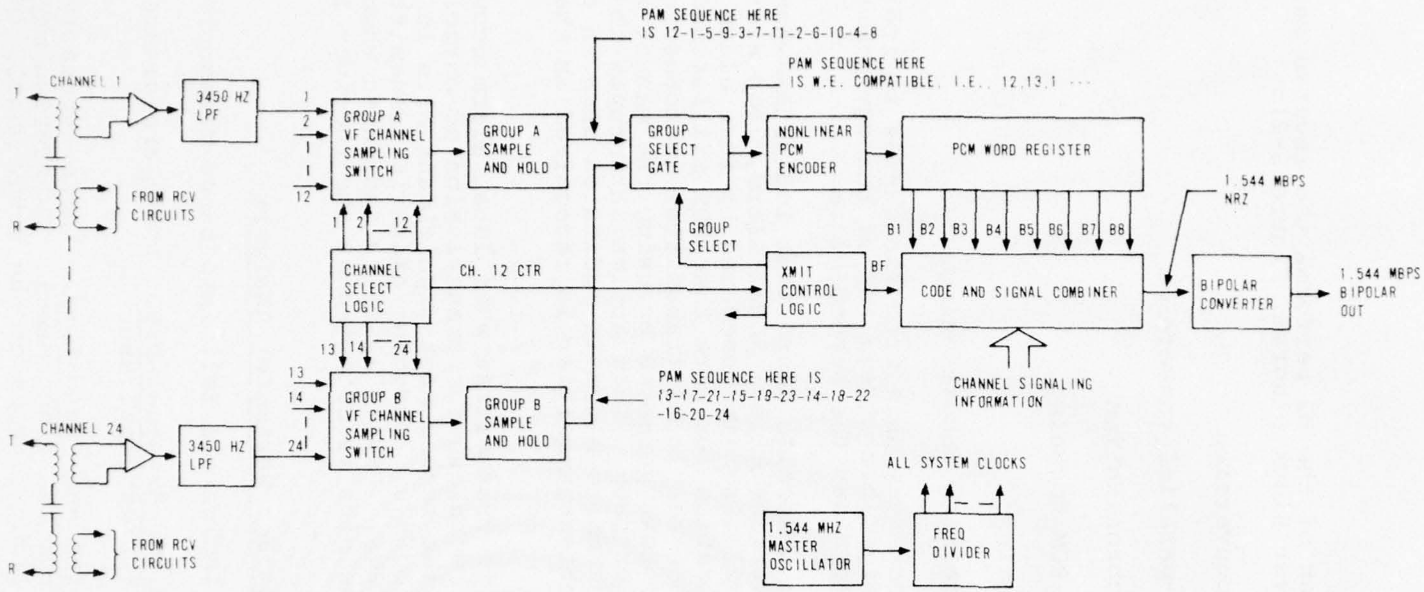


FIGURE 3-1. VICOM D2 TRANSMITTER BLOCK DIAGRAM

The receive section of the D2 performs the inverse sequence of operations (Receiver Block Diagram, Figure 3-2):

- Unipolar conversion
- Serial-to-parallel conversion
- Frame synchronization
- Nonlinear PCM decoding
- Demultiplexing
- VF and signaling conditioning.

Two signals are made available from the CY-104 to indicate the health of the received bit stream and of the equipment. These are the Service Alarm and the Remote Alarm.

Service Alarm is a composite alarm that indicates when any of the following conditions exist; local alarm, loop alarm and remote alarm. Local alarm is generated by fuse alarm or loss of frame synchronization for more than 800 milliseconds. Loop alarm is caused when the local transmitter is connected to the local receiver for test purposes by using the manual switch provided for that purpose. This action interrupts the normal receive function. Remote Alarm is indicated when an outgoing alarm from the remote transmitter is recognized in the local receiver.

An outgoing alarm is transmitted when local alarm occurs within that CY-104. The technique for transmission of outgoing alarm is to force the second most significant bits in all words of the format to logic 0. Outgoing alarm is transmitted for a minimum of 20 seconds. Remote alarm is indicated when the all-zero state of these bits is detected at the receiver for 1.5 seconds.

3.2.2 CY-104 Alarm and Parameter Analysis

CY-104 Alarms and Indicators fall into three categories:

Alarms Intended for External Use. These are alarms brought to a connector for external use.

Front Panel Alarms and Indicators. These currently light lamps visible from the front panel. Extraction may be feasible using light sensors on the front panel. Otherwise,

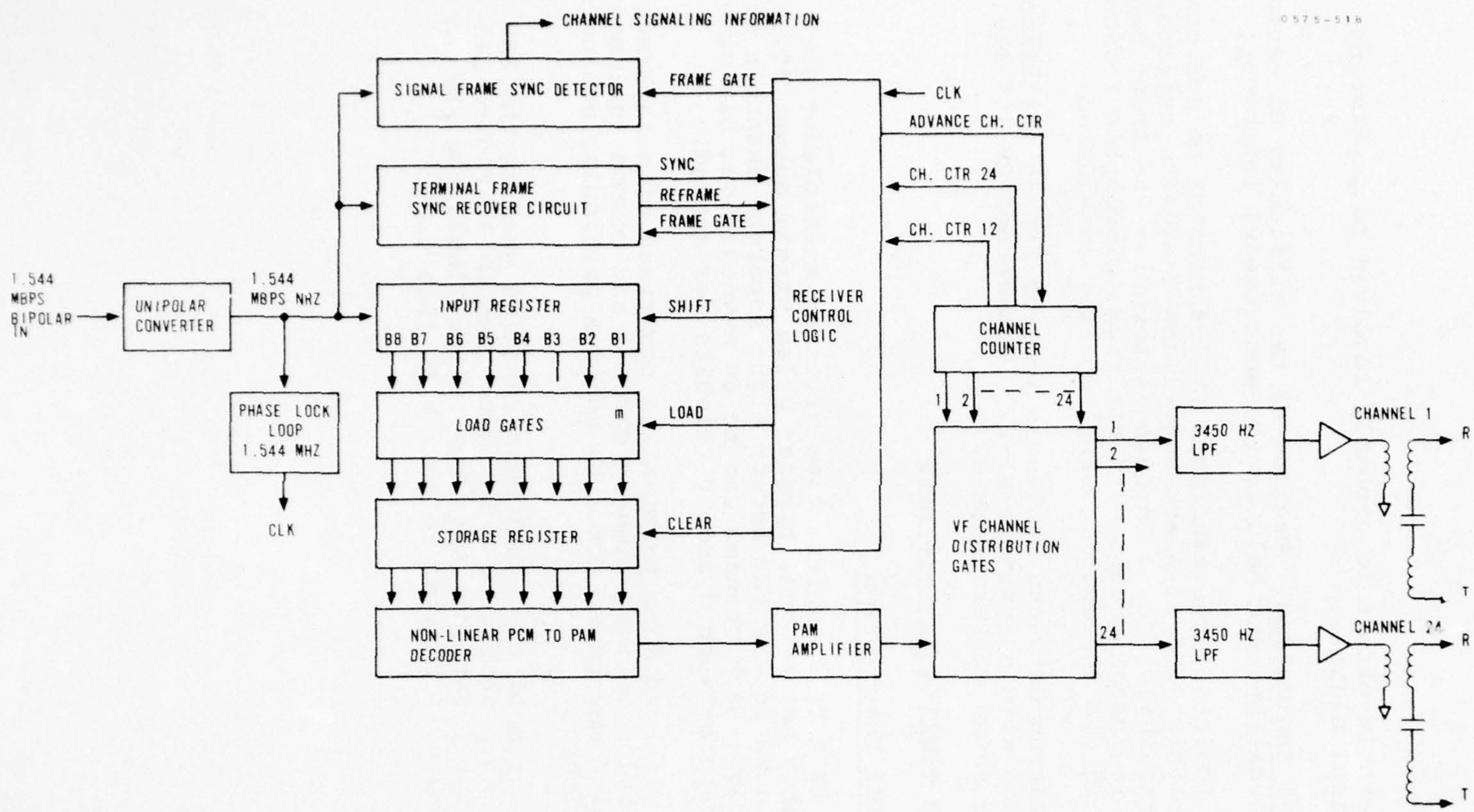


FIGURE 3-2. VICOM D2 RECEIVER BLOCK DIAGRAM

considerable effort is probably involved to provide an electrical signal.

Internal Indicators. Because of the difficulty of extraction, recommendations are held to the most useful indicator.

Table 3-2 indicates the candidate CY-104 monitor points considered in this study. Alarm Nos. 1 and 2 are the external usage alarms while Nos. 3 through 14 comprise the front panel alarm and indicator group. The Bit Frame miscompare indicator, alarm No. 15, is the sole internal monitor considered.

Detailed rating data and rationale for the rating justification is contained within Appendix A2-2. Recommended CY-104 monitor points are shown in Paragraph 3.7.

3.3 VICOM T1WB1 SUBMULTIPLEXER

3.3.1 T1WB1 Description

The T1WB1 is a full duplex, time division multiplexer with a 1.544 megabit per second, bipolar pulse stream output (T1). The units used in the FKV accept eight separate channels for multiplexing. Each channel can be an asynchronous bit stream with bit rate between 0 and 50 kilobits per second.

The T1WB1 wideband data terminal is comprised of a rack-mounted shelf unit plus various plug-in channel and common equipment modules which may be selected to achieve particular equipment configurations.

A block diagram of the T1WB1 configuration used in the FKV system is shown in Figure 3-3. Note that while Figure 3-3 shows input bit rates of 0-64 kbs to the T1WB1, the FKV system input bit rate is bimited to 50 kbs at this time.

TABLE 3-2. CANDIDATE CY-104 ALARM MONITOR POINTS

	Alarm	Description
1.	Remote (HY-12)	Indicates far-end terminal is in LOCAL alarm
2.	LOCAL (HY-12)	Loss of receiver/frame for 0.8 seconds without regaining frame or any dc power failure.
3.	Service (HY-12)	Indicates D2 is in LOCAL alarm.
4.	Frame (HY-12)	D2 channel bank has attempted a reframe. Alarm latches.
5.	Carrier Group (HY-12)	Subscriber channels have been automatically "busied out."
6.	Loop (HY-12)	Transmitter is looped internally to receiver.
7.	Alarm Cutout (HY-12)	External service and remote alarm outputs are deactivated.
8.	Fuse (HY-12)	A fuse has blown internally.
9.	Restart (HN-74)	The unit has stopped attempts to synchronize with distant end push-button reset.
10.	Power (HN-74)	Primary power is ON.
11.	Fuse (HN-74)	A fuse has blown internally.
12.	Power (KG)	Primary power is ON.
13.	Rx Operate (KG)	KG Receiver ready to pass data.
14.	Tx Alarm (KG)	KG transmitter is internally alarmed.
15.	Tx Operate (KG)	KG transmitter ready to pass data.
16.	Frame Bit Miscompare	Detection of a frame bit error.

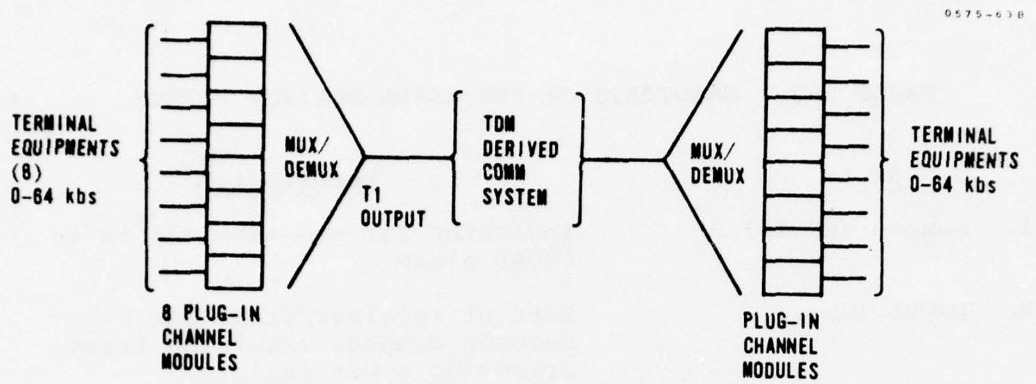


FIGURE 3-3. T1WB1 TERMINAL CONFIGURATION

A brief introduction to the T1WB1 is included here. A more detailed description may be found in Appendix A3.

The T1WB1 transmitter encodes input transitions in logic state, for each channel, into a Tri-Bit Code word comprised of an index bit, a quantize bit, and a state bit.

The index bit is transmitted first to indicate that a transition did occur. The quantizing bit, transmitted second, indicates the phase of the transition relative to two 192 kHz clocks internal to the T1WB1 transmitter.

The state bit indicates the state of the input signal following the transition, either logic 1 or 0.

A simplified block diagram of the T1WB1 transmitter subsystem is shown in Figure 3-4. Data input from the terminal equipment is in unipolar NRZ format and is accepted at the input buffer. Since the T1WB1 encodes data transitions, the input is completely asynchronous at any rate from 0 b/s up to the maximum of 64 kb/s

The encoder provides the necessary circuitry to generate the previously described tri-bit code word for each data transition. The code word bits are held in a register until they are multiplexed into the composite stream.

The retimer and bipolar converter transforms the internally used unipolar NRZ signal to the 50 percent duty cycle bipolar RZ T1 format for output. The T1 signal is passed through a 6 db pad for level adjustment at the last point prior to output to the line.

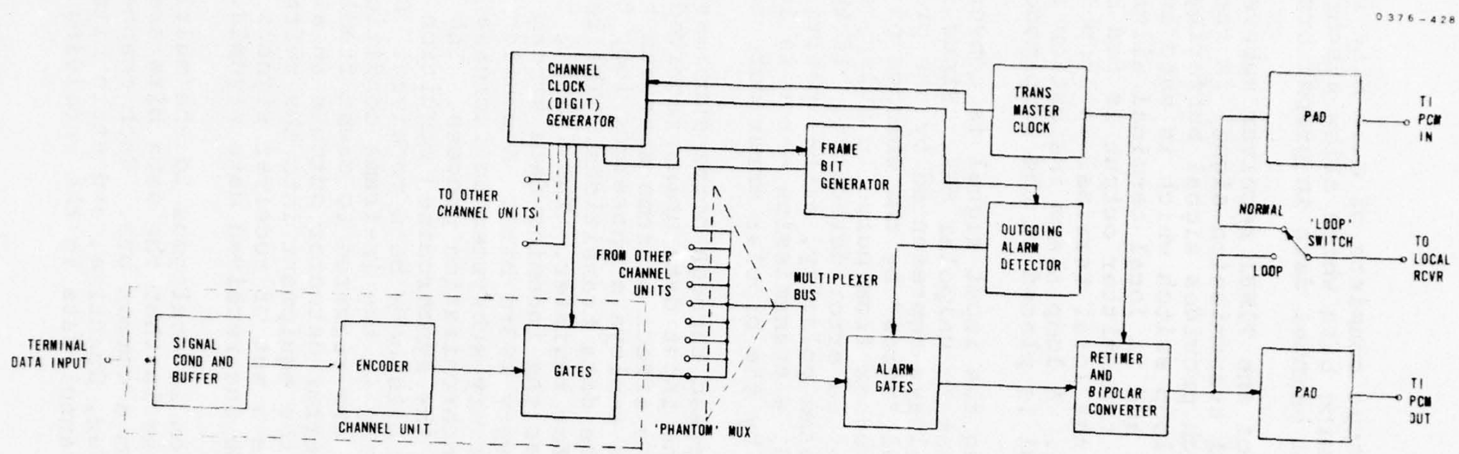


FIGURE 3-4. T1WB1 TRANSMITTER BLOCK DIAGRAM

The composite 1.544 Mb/s output consists of data bits from each input channel plus framing bits which allow synchronization and recovery of the original channel data in proper order.

A simplified block diagram of the T1WB1 receiver subsystem is shown in Figure 3-5. The T1 transmission signal is received at the input interface, which provides signal buffering. It is then routed through the loop switch which is used in certain fault isolation procedures, and in local terminal alignment. In the "loop" position, the transmitter output is fed back to the receiver input so that the local terminal is looped back to itself through the T1WB1. A loop alarm indication is generated whenever the T1WB1 is placed in the loop mode.

The first step in processing the input signal is conversion from the bipolar RZ T1 format to unipolar NRZ. Since in the T1 format logical "ones" are always represented by the presence of a pulse on the line, logical "zeros" by the absence of a pulse, and the polarity always reverses from pulse to pulse, a means is available to perform limited error detection. If two consecutive pulses of the same polarity, either positive or negative, are ever received, a transmission error is indicated. This function is performed by the bipolar error detector.

The input signal is next passed through noise suppression circuitry which reclocks the input data using received data timing, thus eliminating the effect of some spurious transitions. The timing recovery circuit employs a phaselock loop to recover the 1.544 MHz clock from the data transitions. The retimed data is clocked into a buffer register. The framing recovery and clock generator searches the incoming data stream for the alternating framing bit (every 193rd bit). A confidence counter is used in the framing recovery subsystem to increase the "hardness" of the frame synchronization process. The system is not considered to be in the synchronized condition until 7 sequential correct framing bits have been received. Similarly, if the equipment is operating in the in-frame condition, 3 framing errors in a 10-frame period are required to cause framing loss to be assumed. The frame error detector outputs an alarm under this condition and forces the equipment into the reframe mode. The clock generator outputs a set of receiver signals used in the channel units to decode the received data signals.

The demultiplexing operation is analogous to the multiplexing operation in the transmitter in that the data bits are gated into each channel unit from a common bus. Each channel unit decodes its respective Index, Quantize, and State bits and buffers the resulting recovered channel data to the receiving terminal equipment.

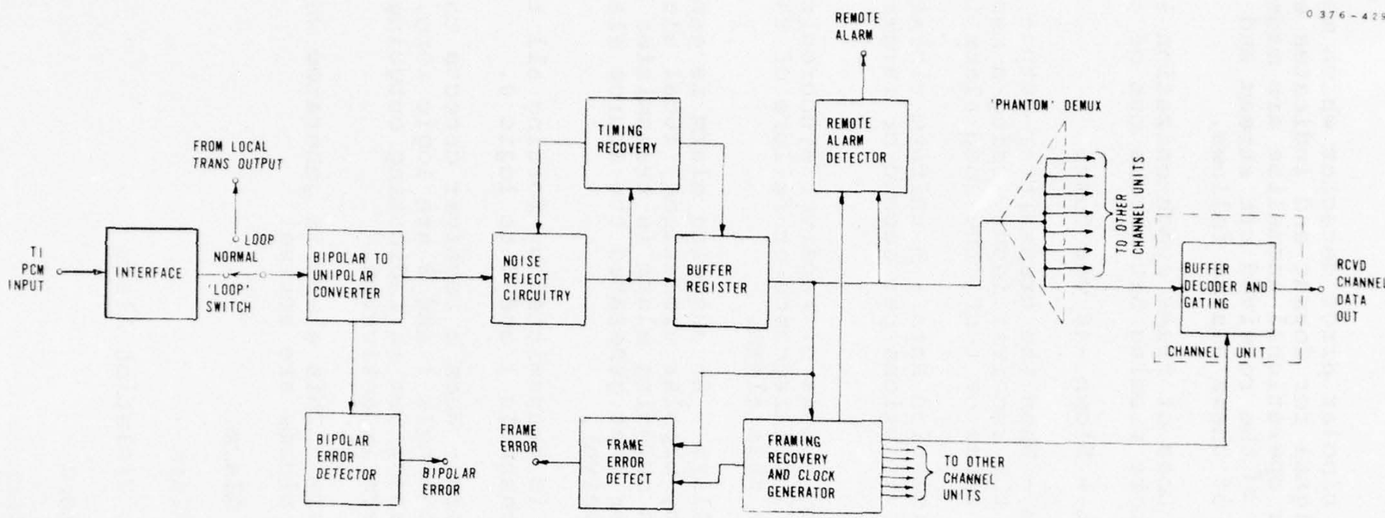


FIGURE 3-5. T1WB1 RECEIVER BLOCK DIAGRAM

In addition to the bipolar error detector which monitors the input 1.544 Mb/s signal for format and indicates errors in transmission, other operational anomalies are made available to sense the health of the received bit stream and of the T1WB1, per se. A listing of these alarms follows.

1. Reframe - Loss of frame synchronization in the receiver, three or more framing bit errors out of ten.

2. Fuse Alarm - Blown -48 vdc fuse.

3. Loop Alarm - When the transmitter output of a unit is looped to the receiver input, using a manual switch for the purpose of test, the loop alarm is activated.

4. Bipolar Violation Rate - A uniform violation rate of 2.6×10^{-5} violations per second or larger will trigger the alarm.

5. Local Alarm - Loss of receiver synchronization for more than 5 milliseconds or failure of the dc supplies will cause this alarm.

6. Outgoing Alarm - An outgoing alarm is generated by fuse alarm, bipolar violations, local alarm or loop alarm. An outgoing alarm is transmitted by the multiplexer that generated the source alarm to the remote receiver.

   The alarm is transmitted by forcing all the transmitted bits for channels 1 and 8 to logic 0.

7. Remote Alarm - When a receiver detects that all the bits for channels 1 and 8 are logic zero, meaning the remote transmitter is indicating outgoing alarm, remote alarm is activated.

8. Office Alarm - This alarm is generated when any of the following alarms are active:

   Remote Alarm

   Local Alarm

   Bipolar Violation Alarm

   Fuse Alarm

   Loop Alarm

   No Power

   Outgoing Alarm Manual Cut-Off Switch

3.3.2 T1WB1 Alarm and Parameter Analysis

A summary of all candidate monitor points considered for the T1WB1 is shown in Table 3-3. A more detailed description is contained in Appendix A3, Paragraph A3-2.

Each candidate was analyzed and rated for usefulness, availability and processing requirements. This data and supporting rationale is given in Appendix A3, Paragraph A3-3.

Recommended monitor points selected are shown in Paragraph 3.7.

3.4 VICOM T1-4000 EIGHT PORT TDM

3.4.1 T1-4000 Description

The T1-4000 is an asynchronous, time division multiplexer capable of multiplexing up to eight channels of 1.544 megabit per second (T1) bit streams into a single 12.5526 megabit per second bit stream. In the FKV, the source of the individual T1-4000 channels are T1WB1 multiplexers and CY104 PCM/TDM terminals.

The output of the T1-4000 transmitter is a three-level partial response signal that is used as the baseband for the line-of-sight radio. The partial response format is implemented by frequency domain filtering, with half of the filtering done in the transmitter output and the other half in the receiver input.

The multiplexer is asynchronous in that the channel input bit streams may have any phase and a limited variation in bit rate. The T1-4000 is designed to accommodate variations in bit rate of +150 to -300 bits per second from nominal.

The VICOM T1-4000 is housed in one terminal shelf unit. The top shelf mounts the common equipment; the lower shelves hold the channel-related hardware. The four-channel unit has two shelves; the eight-channel unit has three.

The multiplexer has circuit modules of ten different types in addition to the terminal shelf unit. Three module types are channel related with each duplex T1 channel having one each. They are the PCM Access Unit 4105, Transmit Channel Unit 4110, and Receive Channel Unit 4120.

The common units are Transmit Time Base 4021, Transmit Control Channel 4022, Interface Unit 4090, Receive Input Unit 4023, Receive Time Base Unit 4024, Receive Control Channel 4025, and Power and Alarm Unit 4010. Each T1-4000 has one each of these modules.

TABLE 3-3. CANDIDATE T1WB1 MONITOR POINTS

Parameter	Description
T1WB1 Receiver	
1. T1 RCVD Bit Stream	T1, bipolar input signal to the receiver
2. Recovered Clock	Bit rate clock recovered from the received T1 input signal
3. Bipolar Violation Error	A pulse that indicates the detection of a bipolar format violation in the received T1 signal
4. Frame Bit Errors	A pulse that indicates the detection of a framing bit error in the receiver
5. RCVD Data After Clocking	This signal is the received T1 data as sampled by the recovered clock
6. Channel Decode Clocks	The receiver generates 8 clocks, each clock having a different phase. Each channel is decoded using 2 of the clocks
7. Framing Bit Clock	The receiver generates a clock that has a pulse once each frame that indicates the time when receipt of a framing bit is expected
8. RCVD Output Data	These signals are the individual channel outputs of the receiver
9. Error Check (Redundancy)	This technique uses the redundancy in the data encoding scheme to monitor for errors in the individual channel outputs at the receiver
10. Bipolar Violation One Shot	A nonretriggerable 25 millisecond pulse triggered by bipolar violation error
11. Timing Phaselock Loop Control Voltage	Control voltage in the receiver PLL which recovers channel data timing

AD-A033 538 HONEYWELL INC ST PETERSBURG FLA AEROSPACE DIV F/G 17/2
ATEC DIGITAL ADAPTATION STUDY. VOLUME I. FKV REQUIREMENTS FOR P--ETC(U)
OCT 76 T R ARMSTRONG, A K BLOUGH F30602-75-C-0282
UNCLASSIFIED 476-13656-VOL-1 RADC-TR-76-302-VOL-1 NL

2 OF 5
ADA033538

TABLE 3-3. CANDIDATE T1WB1 MONITOR POINTS (CONTINUED)

Parameter	Description
T1WB1 Transmitter	
12. Transmitter Clock Source	The output of the transmitter crystal oscillator after frequency division by two using a flip flop
13. Channel Inputs	The individual channel bit streams at the transmitter inputs
14. Transmitter Bus	The common bus in the transmitter that connects the outputs of the individual channel data encoders to the common equipment
15. Channel Clocks (Transmit)	The transmitter generates 8 clocks, each of different phase. The transmitter data for each channel is encoded using 2 of the clocks
16. Tx Frame Bit Clock	The transmitter generates a clock that has one pulse per frame that indicates the time when the framing bit is to be transmitted
17. Frame Bit Generation	In the transmitter, a signal is generated that indicates the state of the next framing bit to be transmitted
18. Tx T1 Output	This signal is the balanced, bipolar T1 output of the transmitter

TABLE 3-3. CANDIDATE T1WB1 MONITOR POINTS (CONTINUED)

Parameter	Description
T1WB1 Power and Alarm Unit	
19. DC Voltages	Monitor the analog voltage levels of the internal dc power supplies.
20. Reframe	This signal indicates that the receiver is attempting to acquire synchronization
21. Fuse Alarm	This signal indicates a blown fuse
22. Loop Alarm	This signal indicates that the receiver input has been connected to the local transmitter output instead of the normal received signal
23. Remote Alarm	This signal indicates that the receiver has detected the alarm code in the received bit stream
24. Bipolar Violation Rate Alarm	This indication is given when the rate of violations in format restrictions at the receiver T1 input exceeds a threshold
25. Local Alarm	This alarm indicates loss of receiver synchronization or loss of the 5, 12 or -9 vdc supply
26. Outgoing Alarm	An alarm is given due to a fuse alarm, bipolar errors in receiver, local alarm, or loop alarm
27. Office Alarm	An alarm is given due to remote alarm, local alarm, bipolar errors in receiver, fuse alarm, loop alarm, outgoing alarm cut off switch, or loss of power

VICOM offers a test module that is not needed for operation. This is the Test Word Generator-Detector 4027.

A simplified block diagram of the T1-4000 multiplexer is shown in Figure 3-6. Performance characteristics and detailed descriptions of the hardware implementation are given in Appendix A4, Paragraph A4-1.

The block diagram points out the more significant concepts employed with the T1-4000 and serves to introduce parameter definitions of monitor point candidates.

On the transmit side, the multiplexer accepts input data in the standard T1 1.544 Mb/s bipolar RZ format. This input data is converted into unipolar NRZ format and transmit timing is recovered from each individual data stream.

Since the input data streams are asynchronous, provision is made to "equalize" them prior to combination. This is done by means of "stuffing" techniques. Bits are added whenever needed to maintain the composite buffer output at exactly 1.544935 Mb/s. When a bit is added, if it contains no information, it is referred to as a "stuff" bit, and at the receive end will be removed and discarded by the demultiplexer. Circuitry associated with the input buffer detects the need for a "stuff" bit and requests this bit through the channel buffer control unit.

The 1.544935 Mb/s data streams from the (up to eight) channel buffers are synchronous and can be simply combined in the channel multiplexer. Identification of the stuff bits, plus the information required to recover the data from the separate T1 channels is added to the composite output in the control and framing subchannels. These are combined with the composite channel data in the frame multiplexer. The output of the frame multiplexer is approximately 1.57 Mb/s times the number of T1 input channels.

The multiplexed bit stream is scrambled before being filtered for partial response spectrum shaping. The purpose of the scrambler is to flatten the frequency spectrum of the baseband spectrum to remove spectral tones that may exist in the format and data content. The scrambler is implemented in such a way that the descrambler in the receiver is self-synchronizing and does not require special synchronizing circuitry. Descrambling is done in the receiver following filtering, clock recovery, and partial response data recovery, but before the format synchronization and demultiplexing functions.

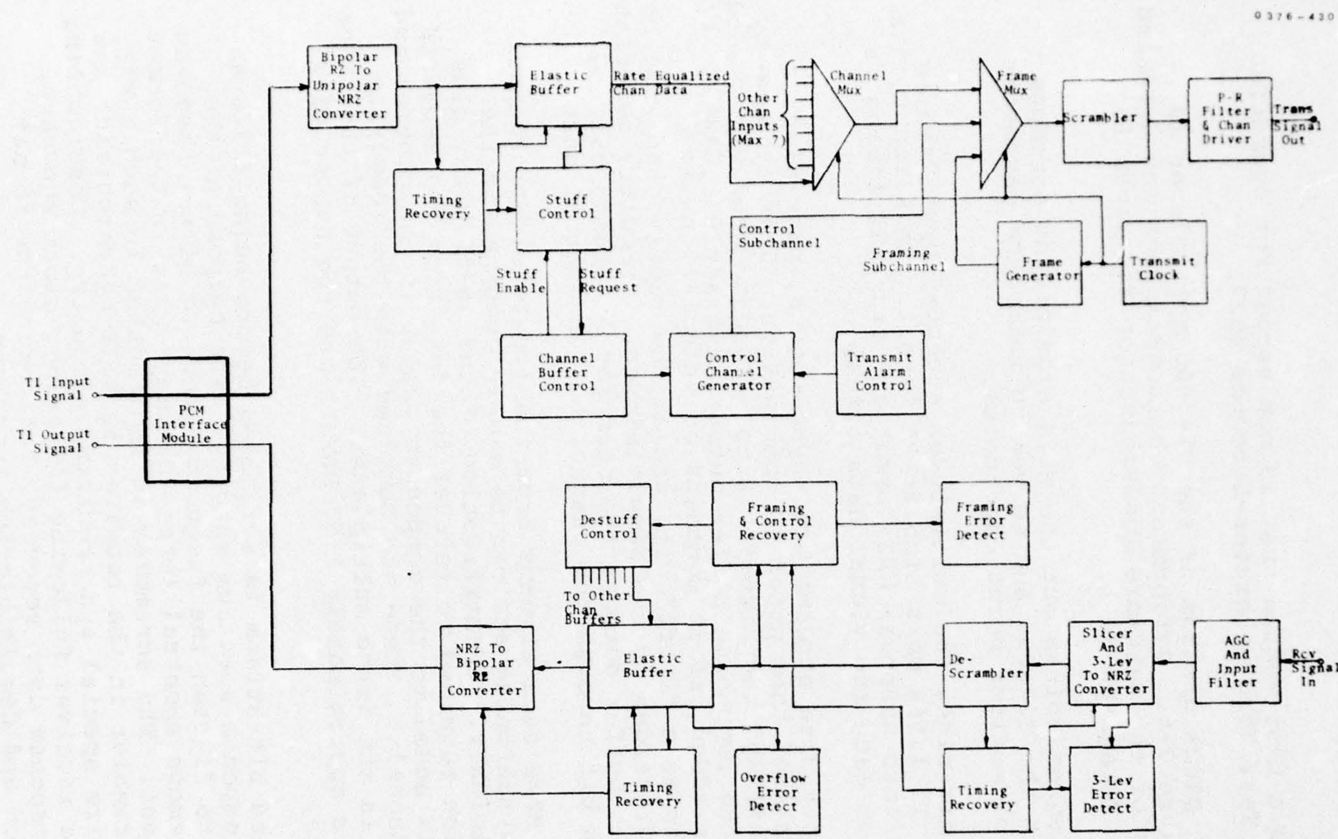


FIGURE 3-6. SIMPLIFIED BLOCK DIAGRAM OF T1-4000 MULTIPLEXER

Framing and control recovery circuitry provides control signals to the output buffers (one for each T1 channel in the multiplex configuration) to appropriately route the individual data bits. The destuff control causes stuff bits to be eliminated as required. Since the input to the output buffer may have abrupt discontinuities as framing, control, and stuff bits are deleted, it is designed to perform a smoothing function. A separate phaselocked loop with a relatively narrow bandwidth is used to recover the average input bit rate. This stabilized clock is then used to strobe data out of the buffer. Alarm circuitry is provided to detect buffer overflow or underflow which may occur under certain error conditions.

The final stage of processing before the data is output is conversion of the unipolar NRZ data stream to the bipolar 50 percent duty cycle RZ form.

The FKV communications network is protected from T1-4000 multiplexer failure by using standby equipment. Switchover to standby is automatically activated when main frame or control frame synchronization is lost in a receiver. The switchover is mechanized using the VICOM 4030 First-Level Multiplexer Protection Switch. A description of operation for the Protection Switch and a flow chart of the switchover sequence is given in Appendix A4, Paragraph A4-1.4.

3.4.2 T1-4000 Alarm and Parameter Analysis

A summary of the monitor points analyzed for the T1-4000 is given in Table 3-4. The alarm and parameter tabulation is subdivided into the four distinct categories: the T1-4000 Receiver, the T1-4000 Transmitter, the Power and Alarm Unit, and the T1-4000 Protection Switch. A more detailed description is contained in Appendix A4, Paragraph A4-3.

Each monitor point candidate was rated for usefulness, availability, and processing. This data and supporting rationale is included as part of Appendix A4, Paragraph A4-4.

Recommended monitor points selected following the analysis are shown in Paragraph 3.7.

TABLE 3-4. CANDIDATE T1-4000 MONITOR POINTS

Parameter	Definition
T1-4000 Receiver	
1. Three-Level Partial Response Input	The input signal to the receiver.
2. Three LPR after Filtering	The input signal to the receiver following the input filter.
3. Three LPR after AGC	The input signal to the receiver following input filtering and gain control.
4. AGC Control Signal	The feedback control signal in the receiver automatic gain control amplifier.
5. High and Low Slicer Outputs	These two digital signals indicate the instantaneous signal amplitude at the AGC output relative to two set thresholds.
6. Derived Clock (Receiver Input)	A bit rate clock derived from the slicer output signals.
7. Phase Error for Derived Clock (Receiver Input)	The phase error signal in the phase locked loop used to recover clock.
8. Three-Level Violation Detector	A pulse is generated when violations in the three-level format are detected in the receiver.
9. Descrambler Output	Received bit stream following descrambling.
10. Main Frame Bit Errors	A pulse is generated when the receiver detects an incorrect framing bit.
11. Elastic Buffer Write Clocks (Receiver)	The receiver generates a separate clock for each received channel, each clock having a different phase.

TABLE 3-4. CANDIDATE T1-4000 MONITOR POINTS (CONTINUED)

Parameter	Definition
T1-4000 Receiver (Cont'd.)	
12. Main Frame Timing	A clock pulse occurs once each main frame that indicates the time when a main framing bit is expected to occur in the received bit stream.
13. Control Frame Marker Errors	A pulse occurs when a received control frame marker code contains an error.
14. Stuff Code Error Monitor	The three stuff control code bits for each channel could be monitored for errors in the receiver.
15. Destuff Rate	A separate destuff enable signal is generated for each received channel.
16. Three-Level Error Density	An indication is given when the three-level violation rate exceeds 10^{-5}.
17. Destuff Timing	Each received channel destuffing is controlled by separate destuff enables and a destuff reset signal.
18. Elastic Buffer Overflow/Underflow	An elastic buffer is used in each received channel to reduce phase jitter at the receiver output.
19. T1 Bipolar Output	Each received channel is outputed in balanced, bipolar format.
20. T1 Received Derived Clock	A bit rate clock is recovered for each received channel to control output clocking of the elastic buffer.
T1-4000 Transmitter	
21. T1 Input Signals	The separate channel, bipolar, transmitter inputs.
22. T1 Bipolar NRZ Converters	The input bit streams of the individual channels to the transmitter after conversion to transistor-transistor logic levels.

TABLE 3-4. CANDIDATE T1-4000 MONITOR POINTS (CONTINUED)

Parameter	Definition
T1-4000 Transmitter (Cont'd.)	
23. T1 Rate Derived Clock (Transmitter)	A bit rate clock is recovered from each channel input to the transmitter.
24. Basic Trasnmitter Clock	The clock source for the transmitter is a crystal oscillator.
25. Stuff Enable	A separate stuff enable is generated for each transmit channel.
26. Elastic Buffer Read Clocks	Each transmit channel elastic buffer is read under control of separate clocks.
27. Stuff Time	A clock signal that occurs once each control frame indicates the time when bits can be stuffed.
28. $\overline{\text{CHAN CLK}}$	The basic clock for the control frame generator.
29. Trasnmit Bit Stream (TTL)	The transmit bit stream at the input to the partial response filter.
30. Analog Trasnmit Signal	Transmitter output signal that goes to the radio.
T1-4000 Power and Alarm Unit	
31. DC Voltages	Monitor the analog voltage levels of the internal dc power supplies.
32. Loop Alarm	Indicates the receiver input is connected to the local transmitter output instead of the normal receive signal.
33. Fuse Alarm	Indicates the fuse on primary power has blown.
34. Minor Alarm/Three Level Error Density	An indication is given when three-level format violation rate of 10^{-5} or greater is detected in the receiver.

TABLE 3-4. CANDIDATE T1-4000 MONITOR POINTS (CONTINUED)

	Parameter	Definition
T1-4000 Power and Alarm Unit (Cont'd.)		
35.	Main Reframe	An indication is given when the receiver is resynchronizing main frame.
36.	Control Reframe	An indication is given when the receiver is resynchronizing control frame.
37.	Send Alarm (Multiplexer)	An indication is given when main or control frame synchronization is lost for more than 250 milliseconds.
38.	Remote Alarm	The receiver detects transmission of a send alarm from the remote transmitter.
39.	Major Alarm (Multiplexer)	An indication is given when a remote alarm occurs, with loss of +20 Vdc or loss of control or main frame synchronization.
T1-4000 Protection Switch		
40.	Major Alarm (Protective Switch)	An indication is given when transfer attempt failed, standby multiplexer has local alarm while transferred, remote alarm received, or switch unit on standby.
41.	Minor Alarm (Protective Switch)	An indication is given when receiver or transmitter is transferred, automatic transfer disabled, switch unit loses power, or standby multiplexer is in local alarm.
42.	DC Power	Power is supplied by the multiplexers.
43.	Send Alarm (Protective Switch)	An indication is given when main or control frame synchronization is lost for more than 20 milliseconds.
44.	Remote Alarm	A send alrrm from the remote transmitter has been detected.

TABLE 3-4. CANDIDATE T1-4000 MONITOR POINTS (CONTINUED)

Parameter	Definition
T1-4000 Protection Switch (Cont'd.)	
45. Tx Transfer Status	Indication when standby transmitter is switched on line.
46. Tx Transfer Latched	Indication when standby transmitter is latched to on-line operation.
47. Rx Transfer Status	Indication when standby receiver is switched on-line.
48. Rx Transfer Latched	Indication when standby receiver is latched to on-line operation.

3.5 AN/FRC-162(V) LOS FM RADIO

3.5.1 AN/FRC-162 Description

Line-of-sight (LOS) microwave radios provide intersite communications for facilities within the Frankfurt-Koenigstuhl-Vaihingen (FKV) digital transmission system. This section addresses the radio operation, its performance characteristics, and its monitoring potentialities.

The LOS microwave radio used in the FKV system is the AN/FRC-162(V) Radio Set. This radio set is a modified Collins Radio MW-518. It is a space-diversity, full duplex, microwave transmitting and receiving terminal that operates on fixed frequencies in the 7125 MHz to 8400 MHz band. The radio set transmits a nominal 1-watt and is capable of wideband data transmission and reception at up to 12.6 megabits per second plus order wire and pilot signals.

The radio set uses full duplex space-diversity techniques and provides reliable communications over the same LOS path via dual receivers. Two transmitters are used, one in-service and one in hot standby, to provide redundancy of the transmitter function. A simplified block diagram of the radio set is shown in Figure 3-7. Space-diversity operation of the radio set is accomplished by using separate, vertically spaced antennas, each connected to one of the two receivers. Both receivers operate on the same frequency. Both transmitters and one receiver share a common antenna via a circulator which isolates the transmit and receive signals. The other receiver has an antenna to itself.

Detailed operational descriptions of the AN/FRC-162 radio are contained within Appendix A5.

3.5.1.1 Expected Link Behavior

Performance assessment of a radio link should be done in the context of having some knowledge of the expected behavior of the link. Radio paths are not static; their characteristics vary with meteorological conditions and with external factors.

Appendix A5, Paragraph A5-2.3 contains an analysis of the types of deviation from normal, stable conditions which can arise from natural and external factors during operation of the FKV network. The results are summarized below.

a. Reference received signal level (RSL) is considered to be that level existing when the atmosphere is well mixed and clear; conditions which occur most frequently in early afternoon. Under these conditions, RSL should be equal at both receiving antennas, with small fluctuations, on the order of a decibel.

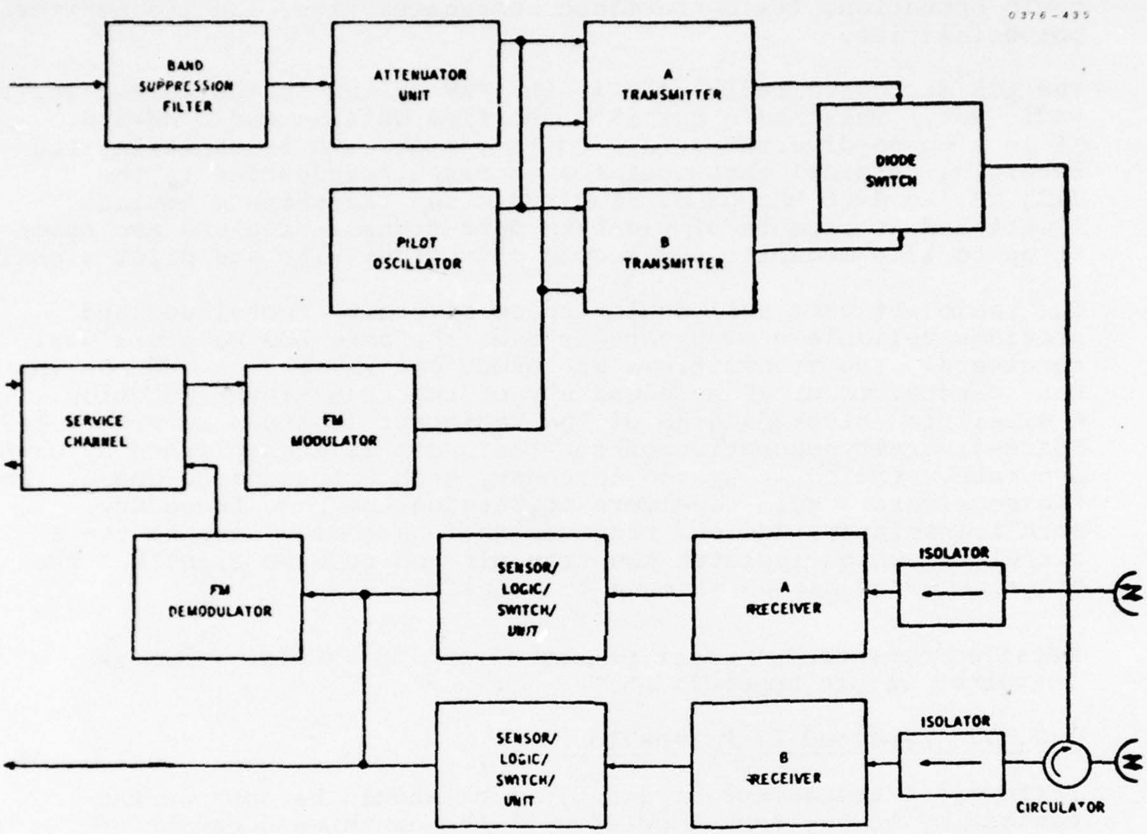


FIGURE 3-7. RADIO SET SIMPLIFIED BLOCK DIAGRAM

b. Rainfall will cause flat fading along the paths with equal effects in both legs of the diversity system. Except in most severe conditons, it should not, itself, create enough attenuation to cause RSL to go below threshold.

c. Protection against multipath fading is the primary reason for using a space diversity system. Multipath fading is of such a nature that simultaneous deep fades rarely occur on both receiving antennas of a space diversity pair. It is most likely to occur when the atmosphere is calm and stratified, in the late and early morning hours.

d. In the FKV network, considerable multipath fading can be expected on the longer links; those between Koenigstuhl and Stocksberg and Stuttgart.

e. Statistically stationary radio interference can reduce the effective fade margin of the system, while being of such small amplitude relative to the FM carrier that it is negligible in its contribution to total received signal plus noise power.

f. Bursts of noise pulses, either from natural or man-made sources, are potentially disruptive, and, unless their effects are specifically watched for, can disturb system operation in ways which make inference of probable cause difficult.

3.5.2 Parameter and Alarm Analysis

The radio set is well instrumented with hard alarms. Most of these are brought to external connectors on the top of the radio set, intended for connection of alarm monitors.

Most of the alarms are activated when the value of an analog parameter crosses a threshold, which is set during alignment of the radio set.

The alarms available, the conditions for activation, and the adjustability of the threshold are listed in Appendix A5, Paragraph A5-3.

Some analog parameters are available, which can be utilized to assess, in a quantitive sense, the health of the radio set. Some of these are also dependent upon the calibration and adjustment of the radio set. These parameters, the quantities they represent, availability and adjustability are listed in Appendix A5, Paragraph A5-3.

Indicators are available which show the operating configuration of the radio set; i.e., normal switching inhibited, in-service (A or B) for both receiver and transmitter, without direct regard to performance or fault status. These are listed in Appendix A5, Paragraph A5-3.

Table 3-5 summarizes the candidate monitor points analyzed for the AN/FRC-162 Radio System. Each candidate was rated for usefulness, availability and ease of processing. This data and supporting rationale are given in Appendix A5, Paragraph A5-4.

Recommended monitor points selected following the analysis are shown in Paragraph 3.7.

TABLE 3-5. CANDIDATE RADIO SYSTEM MONITOR POINTS

Parameter	Description
Radio System Alarm	
1. Tx PWR (A&B)	Transmitter RF power output below preset threshold. Indicates RF amplifier and doubler chain degraded.
2. Tx AFC (A&B)	Transmitter AFC voltage beyond normal control range and/or phase-lock to reference oscillator lost.
3. Tx Pilot (A&B)	Pilot level, indicating deviation, as sensed at 2 gHz and demodulated, is below preset threshold. Indicates probable failure of transmitter baseband, modulator, or RF circuits.
4. Tx Pilot Oscillator (Com BB)	Pilot oscillator output below preset threshold.
5. FM Subcarrier (Com - Transmit)	Transmitted supervisory subcarrier level below preset threshold. Indicates supervisory channel degraded or lost.
6. Rx Switch (A&B)	Received and demodulated pilot level below preset threshold. Indicates possible loss of baseband intelligence.
7. Rx Squelch (A&B)	Received signal level below preset threshold. Indicates noisy output caused by low received signal.

TABLE 3-5. CANDIDATE RADIO SYSTEM MONITOR POINTS (CONTINUED)

Parameter	Description
Radio System Alarm (Continued)	
8. Rx Phaselock (A&B)	Receiver local oscillator has lost phaselock with crystal controlled reference.
9. Rx Switch Control (Com BB)	Malfunction detected in receiver baseband switching circuitry. Indicates normal diversity selection process impaired.
10. Rx SUBCXR DEMOD (Com BB)	Received supervisory subcarrier level below preset threshold. Indicates supervisory channel degraded or lost.
11. Tx/Rx Power (A&B)	Loss of either +24 or -26 Vdc supplies which operate major part of transceiver.
12. Ancillary Power (A&B)	Loss of -20 Vdc supply which powers ancillary (but important) units.
13. Primary Power (A&B)	Loss of 48 Vdc station power.
14. Fuse Alarm	Any one or more of fuses has blown.
Radio System Status Indicators	
15. Tx Off Normal	Selector switch thrown to allow selected transmitter to pass traffic. Protective switchover prevented.
16. Tx In Service (A&B)	Indicated transmitter is passing traffic.
17. Tx Transmitter Fault	One or more of the transmitter alarms (power, frequency, pilot) in either transmitter is active.
18. Rx Off Normal	Selector switch thrown to allow selected receiver to pass traffic. Diversity switching prevented.
19. Rx In Service (A&B)	Indicated receiver is passing traffic.

TABLE 3-5. CANDIDATE RADIO SYSTEM MONITOR POINTS (CONTINUED)

Parameter	Description
Radio System Parameters	
20. "A" Receiver AGC 21. "B" Receiver AGC	In-band RF energy level reaching receiver.
22. "A" Receiver Frequency 23. "B" Receiver Frequency	Difference between center frequency of receiver demodulator and received signal.
24. "A" Receiver Pilot 25. "B" Receiver Pilot	Change indicates presumptive change in baseband gain of Tx or Rx or of modulator or demodulator sensitivity.
26. "A" Receiver Slot Noise 27. "B" Receiver Slot Noise	Correlatable to AGC to determine change in receiver noise and intermodulation noise.
28. "A" Receiver Dev Test 29. "B" Receiver Dev Test	Same as receiver pilot, measured at front panel meter.
30. Receiver Baseband Waveform Comparison	Difference between "A" and "B" receiver baseband waveforms. Shows difference in transfer characteristics of A and B channels.
31. "A" Tx Power 32. "B" Tx Power	RF power output of transmitter, sensed at directional coupler in waveguide.
33. "A" Tx Frequency 34. "B" Tx Frequency	Control voltage, derived from comparison with reference oscillator, applied to transmitter modulator.
35. "A" Tx Dev Test 36. "B" Tx Dev Test	Amplitude of pilot, sensed at 2 gHz coupler and demodulated. Proportional to transmitter deviation sensitivity.
37. "A" Noise Burst 38. "B" Noise Burst	Indicative of RF noise burst.

3.6 MONITOR POINT SELECTION CRITERIA

3.6.1 Candidate Monitor Point List Evaluation

Parameters, identified and discussed in Paragraphs 3.2 through 3.5 for each of the FKV equipments, were collectively tabulated as the initial Candidate Monitor Point List.

Initial reductions of this list were accomplished via the use of a weighted parameter selection matrix. Ratings were assigned each monitor point in the categories of usefulness, availability, and processing required. This systems analysis technique ultimately generates a number for the "goodness" of each monitor point. These goodness values provide a quantitative means of relative comparison of the candidate monitor points.

Each category has a rating range of 1 to 4 using integer values only. The exact meaning of each rating for the three categories is presented in Paragraph 3.6.2.

The "goodness" of each monitor point is calculated by summing four times the usefulness, two times the availability, and one times the processing values:

$$\text{GOODNESS} = 4(\text{USEFULNESS}) + 2(\text{AVAILABILITY}) + \text{PROCESSING}$$

In general terms, the reason for selecting the weighting factor of 2 for availability and 1 for processing is the relative difficulty and expense of modifying existing equipment to make a signal available for monitoring compared to the cost of processing the signal once it is available.

The weighting factor of 4 for usefulness reflects the fact that the usefulness of a monitor point outweighs the importance of availability and processing combined in the selection process.

A cut-off value of goodness has been established for separating the candidate monitor points into two groups; recommended and not recommended for monitoring.

This value was selected so that any monitor point rated four in usefulness, the highest rating, will be recommended even when the availability and processing are both rated one. For this case the goodness value is 19.

$$G = 4(4) + 2(1) + 1 = 19$$

Therefore, any monitor point with a goodness rating of 19 or larger will be further considered for monitoring. The final list will be determined as a result of applying the constraints

resulting from the monitoring system approach selected for the FKV digital transmission system.

3.6.2 Matrix Rating System Definitions

3.6.2.1 Usefulness

Necessary or Very Useful; Weight Factor: (4)

Absolutely required, cannot be done without or, subjectively, regarded as being of a high degree of service in the area of performance assessment or fault isolation, as the case may be.

For example, the output of the three level violation detector in the T1-4000 multiplexer is given a rating of 4 for performance assessment as this is one of the parameters which may be processed to yield a presumptive measure of the BER on the link from the digital transmitter encoder of the high-order multiplexer, through the radio link, through the digital data stream reconstruction in the high order multiplexer receiver.

Useful - (3)

Not believed to be necessary but being regarded as adding significant information to, or considerably simplifying, the tasks of performance assessment or fault isolation.

Parameters in this range are best rated by comparison to the upper and lower bounds of this range which are the ratings of 4 and 2.

For example, the three level partial response input to the T1-4000 is given a rating of 3 for fault isolation. This is due to the fact that while loss of input to the multiplexer receiver is a valuable piece of information for fault isolation,it is not necessary since this condition could be diagnosed from other alarms. Specifically, the FM subcarrier demodulator alarm in the radio system and the loss of multiplexer synchronization and/or 50 percent main frame bit errors would indicate loss of baseband output from the radios. Obviously, however, an activity monitor on the analog input to the multiplexer would simplify the fault isolation process.

Marginally Useful - (2)

Parameters in this rating are considered marginally useful for fault isolation within an equipment but are considered to be of little value for system level performance assessment or fault isolation, given that higher valued monitor points are available.

For example, the T1-4000 receiver AGC control signal is given a rating of 2 for fault isolation. Monitoring this signal adds some infomration to the problem of fault isolation within the equipment but since the AGC gain is not expected to vary significantly with variations in the RF signal, its contribution is of little value for system performance assessment or fault isolation.

Another example of a fault isolation rating of 2 is the T1-4000 multiplexer driven clock. An activity monitor on this clock would contribute some information if the clock failed but a multiplexer receiver failure (due to the clock failure or another failure) would be manifest in numerous other higher valued monitor points such as main frame bit errors, main reframe, and control reframe.

Not Useful - (1)

Parameters in this category are deemed to contribute no significant information to the process of performance assessment or fault isolation.

For example, presence or absence of a clock signal internal to an equipment contributes nothing to performance assessment of that equipment.

3.6.2.2 Availability

Externally Available with No Buffer - (4)

Signals in this category are provided by the equipment manufacturer as monitor points for external monitoring equipment.

Typically, the signals take the form of relay contact closures; examples being the major alarms in the radio system.

Card Connector with No Buffering - (3)

These signals are available at the connector level and are not expected to require electrical buffering before being inputed to the ATEC monitoring device which may be remotely located.

Examples are dc output voltages and signals which interface between various equipments such as between the radio and T1-4000.

Card Connector with Buffering - (2)

These signals are available at the connector level but require buffering at the extraction or connection point in order that the internal signal is not loaded by wiring capacitance or contaminated by noise.

Examples are internal TTL signals which are employed by the multiplexers.

Internal to Circuit Board - (1)

These signals must be accessed at the circuit board level, necessitating a wire from the access point to a card connector. In most cases, since the signal is TTL or low-level analog, buffering is required.

An example of such a signal is an internal phaselock loop control voltage which is only available on the emitter of a transistor.

3.6.2.3 Processing

No Processing Required - (4)

No special software or hardware processing required before the parameter is inputed to existing ATEC hardware/software for further operations.

Examples of this category are contact closure alarms.

Software Processing Only - (3)

Parameters in this category require only ATEC software modifications prior to processing by existing ATEC software.

The T1-4000 receiver AGC control signal is an example since it is a low-bandwidth analog signal which can be input to the computer by means of existing ATEC hardware but which will require the development of new software to analyze the signal for performance assessment and trending.

Hardware Processing Only - (2)

Parameters in this category require processing by specialized hardware before they are in a form suitable for processing by existing ATEC software or by existing ATEC software with minimal change.

Examples are error rate counters or analog and digital activity indicators. It should be noted that buffering is not considered to be hardware processing.

Software and Hardware Processing - (1)

Parameters in this category not only require that additional software be developed but also require that complex or specialized hardware be developed.

An example is the radio receiver baseband waveform comparison which would require highly specialized hardware as well as specialized software for subsequent processing and extraction of the desired signal characteristics.

3.6.3 Preliminary Recommended Monitor Point List

Tables 3-6 through 3-17 tabulate all parameters considered from the Candidate Monitor Point List and reflect the summation of weighted "goodness" ratings.

Those items which meet the 19-point criteria, or which possess unique selection basis, are shown in the "Recommended" column of the tables. These (asterisked) items comprise the Preliminary Recommended Monitor Point List and indicate those parameters which were considered in subsequent system-level trade-off studies.

TABLE 3-6. SELECTION MATRIX RADIO SYSTEM ALARMS

	Use				Goodness		
Alarm	PA/TA	FI	Aval	Proc	PA/TA	FI	Recommend
1. XMT PWR (A&B)	1	4	4	4	16	28	*
2. XMT AFC (A&B)	1	4	4	4	16	28	*
3. XMT PILOT (A&B)	1	4	4	4	16	28	*
4. XMT PILOT OSC (COM BB)	1	2	3	4	14	18	
5. FM SUBCARRIER (COM BB)	4	4	3	4	26	26	*
6. RCV SWITCH (A&B)	1	4	4	4	16	28	*
7. RCV SQUELCH (A&B)	4	4	4	2	26	26	*
8. RCV PHASELOCK (A&B)	1	2	4	4	16	20	*
9. RCV SW CONTROL (COM BB)	3	3	3	4	22	22	*
10. RCV SUBCXR DEMOD (COM BB)	4	4	3	4	26	26	*
11. XMT/RCV POWER SUPPLY (A&B)	1	2	4	4	16	20	*
12. ANC POWER SUPPLY (A&B)	1	2	4	4	16	20	*
13. PRIMARY POWER (A&B)	1	2	4	4	16	20	*
14. FUSE ALARM	1	2	3	4	14	18	

TABLE 3-7. SELECTION MATRIX RADIO SYSTEM STATUS INDICATORS

Indicator	Use PA/TA	Use FI	Use Aval	Use Proc	Goodness PA/TA	Goodness FI	Recommend
15. TX OFF NORMAL	1	3	1	4	10	18	
16. TX IN-SERVICE (A&B)	4	3	3	4	26	22	*
17. TX XMT FAULT	1	1	1	4	10	10	
18. RX OFF NORMAL	1	3	3	4	14	22	*
19. RX IN-SERVICE (A&B)	4	3	3	4	26	22	*

TABLE 3-8. SELECTION MATRIX RADIO SYSTEM PARAMETERS

Parameter	Use PA/TA	Use FI	Use Aval	Use Proc	Goodness PA/TA	Goodness FI	Recommend
20. "A" RECEIVER AGC	4	4	3	2	24	24	*
21. "B" RECEIVER AGC	4	4	3	2	24	24	*
22. "A" RECEIVER FREQ	1	3	3	4	14	22	*
23. "B" RECEIVER FREQ	1	3	3	4	14	22	*
24. "A" RECEIVER PILOT	1	3	3	4	14	22	*
25. "B" RECEIVER PILOT	1	3	3	4	14	22	*
26. "A" RCVR SLOT NOISE	2	2	4	3	19	19	(Note 1)*
27. "B" RCVR SLOT NOISE	2	2	4	3	19	19	(Note 1)*
28. "A" RCVR DEV TEST	1	2	1	4	10	14	(Note 2)
29. "B" RCVR DEV TEST	1	2	1	4	10	14	(Note 2)
30. RCVR BB WAVEFORM COMPARISON	2	2	4	1	17	17	
31. "A" TX POWER	3	3	3	4	22	22	*
32. "B" TX POWER	3	3	3	4	22	22	*
33. "A" TX FREQ	1	3	3	4	14	22	(Note 2)*
34. "B" TX FREQ	1	3	3	4	14	22	(Note 2)*

NOTES: (1) Recommended for Baseband Repeater Sites for degradation and fault isolation

(2) Requires Control of Functions on Subsystem Control Unit

TABLE 3-9. SELECTION MATRIX ADDITIONAL RADIO SYSTEM PARAMETERS

	Use				Goodness		
	PA/TA	FI	Aval	PROC	PA/TA	FI	Recommend
35. "A" TX DEV TEST	1	3	1	4	10	18	(Note 2)
36. "B" TX DEV TEST	1	3	1	4	10	18	(Note 2)
37. "A" NOISE BURST	2	4	(1 to 4)	1	(11 to 17)	(19 to 25)	(Note 1)*
38. "B" NOISE BURST	2	4	(1 to 4)	1	(11 to 17)	(19 to 25)	(Note 1)*

NOTES: (1) Dependent upon instrumentation

(2) Requires Control of Functions on Subsystem Control Unit

TABLE 3-10. SELECTION MATRIX T1-4000 RECEIVER MONITOR POINTS

	Use				Goodness		
	PA/TA	FI	Aval	Proc	PA/TA	FI	Recommend
1. 3 LEVEL PARTIAL RESPONSE INPUT	2	4	3	1	15	23	Not recommended, Similar to 3 LPR after AGC
2. 3 LPR AFTER FILTERING	2	1	1	1	11	7	
3. 3 LPR AFTER AGC	4	4	1	2	20	20	*
4. AGC CONTROL SIGNAL	2	2	1	3	13	13	
5. HI AND LOW SLICER OUTPUTS	2	2	2	2	14	14	
6. DERIVED CLOCK	1	2	2	2	10	14	
7. PHASE ERROR FOR DERIVED CLOCK	2	2	1	2	12	12	
8. 3 LEVEL VIOLATION DETECTOR	4	3	1	2	20	16	*
9. DESCRAMBLER OUTPUT	1	1	2	2	10	10	
10. MAIN FRAME BIT ERRORS	4	3	1	2	20	16	*
11. ELASTIC BUFFER WRITE CLOCKS	1	2	2	2	10	14	
12. MAIN FRAME TIMING	1	2	2	2	10	14	
13. CONTROL FRAME MARKER ERRORS	2	2	1	2	12	12	
14. STUFF CODE ERROR MONITOR	2	2	1	2	12	12	
15. DESTUFF RATE	2	2	2	2	14	14	
16. 3 LEVEL ERROR DENSITY	3	2	2	2	18	14	
17. DESTUFF TIMING	1	2	2	2	10	14	
18. ELASTIC BUFFER OVERFLOW/ UNDERFLOW	2	3	1	2	12	16	
19. TI BIPOLAR OUTPUT	1	3	3	2	12	20	*
20. TI RECEIVED DERIVED CLOCK	1	2	1	2	8	12	

TABLE 3-11. SELECTION MATRIX T1-4000 TRANSMITTER MONITOR POINTS

	Use				Goodness		
Parameter	PA/TA	FI	Aval	Proc	PA/TA	FI	Recommend
21. TI INPUT SIGNALS	1	3	3	2	12	20	*
22. TI BIPOLAR NRZ CONV	1	2	1	2	8	12	
23. TI RATE DERIVED CLOCK	2	2	1	2	12	12	
24. BASIC TX CLOCK	1	3	1	2	8	16	
25. STUFF ENABLE	1	2	2	2	10	14	
26. ELASTIC BUFFER READ CLK	1	2	2	2	10	14	
27. STUFF TIME	1	2	2	2	10	14	
28. $\overline{\text{CHAN CLK}}$	1	2	2	2	10	14	
29. TX BIT STREAM (TTL)	1	2	2	2	10	14	
30. ANALOG TX SIGNAL	4	3	3	1	23	19	*

TABLE 3-12. SELECTION MATRIX T1-4000 POWER AND ALARM UNIT MONITOR POINTS

	Use				Goodness		
Parameter	PA/TA	FI	Aval	Proc	PA/TA	FI	Recommend
31. DC VOLTAGES	3	4	3	4	21	26	*
32. LOOP ALARM	1	4	2	4	12	24	*
33. FUSE ALARM	1	4	1	4	10	22	*
34. MINOR ALARM/THREE LEVEL ERROR DENSITY	4	3	2	2	22	18	*
35. MAIN REFRAME	4	4	2	2	22	22	*
36. CONTROL REFRAME	3	3	2	2	18	18	
37. SEND ALARM	2	4	2	4	16	24	Not recommended, Similar to protective switch send alarm
38. REMOTE ALARM	2	2	2	4	16	16	
39. MAJOR ALARM	3	4	4	4	24	28	*

TABLE 3-13. SELECTION MATRIX T1-4000 PROTECTION SWITCH MONITOR POINTS

Parameter	Use PA/TA	Use FI	Aval	Proc	Goodness PA/TA	Goodness FI	Recommend
40. MAJOR ALARM	2	4	4	4	30	28	*
41. MINOR ALARM	2	3	4	4	20	24	*
42. DC POWER	3	4	3	4	22	26	Not recommended, same as standby MUX
43. SEND ALARM	3	4	2	4	20	24	*
44. REMOTE ALARM	2	2	2	4	16	16	
45. TX TRANSFER STATUS	3	4	2	4	20	24	*
46. TX TRANSFER LATCHED	3	3	1	4	18	18	
47. RX TRANSFER STATUS	3	4	2	4	20	24	*
48. RX TRANSFER LATCHED	3	3	1	4	18	18	

TABLE 3-14. SELECTION MATRIX T1WB1 RECEIVER MONITOR POINTS

Parameter	Use PA/TA	Use FI	Aval	Proc	Goodness PA/TA	Goodness FI	Recommend
1. TI RCVD BIT STREAM	1	3	3	2	12	20	*
2. RECOVERED CLOCK	1	2	1	2	8	12	
3. BIPOLAR VIOLATION ERROR	2	2	2	2	14	14	
4. FRAME BIT ERRORS	4	4	1	1	19	19	*
5. RCVD DATA AFTER CLOCKING	1	1	2	2	10	10	
6. CHANNEL DECODE CLOCKS	1	2	2	2	10	14	
7. FRAMING BIT CLOCK	1	3	1	2	8	16	
8. RCV OUTPUT DATA	1	3	2	2	10	18	
9. ERROR CHECK (REDUNDANCY)	4	3	1	1	19	15	*
10. BIPOLAR VIOLATION ONE SHOT	2	2	2	2	14	14	
11. TIMING PHASELOCK LOOP CONTROL VOLTAGE	2	1	1	1	11	7	

TABLE 3-15. SELECTION MATRIX T1WB1 TRANSMITTER MONITOR POINTS

Parameter	Use PA/TA	Use FI	Aval	Proc	Goodness PA/TA	Goodness FI	Recommend
12. TRANS CLOCK SOURCE	1	2	1	2	8	12	
13. CHANNEL INPUTS	1	3	1	2	8	16	
14 TRANSMITTER BUS	1	2	2	2	10	14	
15. CHANNEL CLOCKS (TRANSMIT)	1	2	2	2	10	14	
16. TX FRAME BIT CLOCK	1	3	1	2	8	16	
17. FRAME BIT GENERATION	1	2	1	2	8	12	
18. TX T1 OUTPUT	1	3	3	2	12	20	*

TABLE 3-16. SELECTION MATRIX T1WB1 POWER
AND ALARM UNIT MONITOR POINTS

Parameter	Use PA/TA	Use FI	Aval	Proc	Goodness PA/TA	Goodness FI	Recommend
19. DC VOLTAGES	3	4	3	3	21	25	*
20. REFRAME	4	4	1	3	21	21	*
21. FUSE ALARM	1	4	1	4	10	22	*
22. LOOP ALARM	1	4	1	4	10	22	*
23. REMOTE ALARM	2	2	1	4	14	14	
24. BIPOLAR VIOLATION RATE ALARM	2	2	1	2	12	12	
25. LOCAL ALARM	2	2	1	4	14	14	
26. OUTGOING ALARM	2	2	1	3	9	9	
27. OFFICE ALARM	2	4	4	4	20	28	*

TABLE 3-17. SELECTION MATRIX CY-104 ALARM MONITOR POINTS

	Parameter	Use PA/TA	Use FI	Aval	Proc	Goodness PA/TA	Goodness FI	Recommend
1.	REMOTE ALARM (HY-12)	2	2	4	4	20	20	*
2.	LOCAL (HY-12)	1	2	2	2	10	14	(Note 1)
3.	SERVICE ALARM (HY-12)	3	4	4	4	24	28	*
4.	FRAME (HY-12)	3	1	2	2	18	10	(Notes 1 & 2)
5.	CARRIER GROUP (HY-12)	1	1	2	4	12	12	(Note 1)
6.	LOOP (HY-12)	1	4	2	4	12	12	(Note 1)
7.	ALARM CUTOUT (HY-12)	1	1	2	4	12	12	(Note 1)
8.	FUSE (HY-12)	1	2	2	4	12	16	(Note 1)
9.	RESTART (HN-74)	1	4	2	4	12	24	(Note 1)*
10.	POWER (HN-74)	1	1	2	4	12	12	(Note 1)
11.	FUSE (HN-74)	1	2	2	4	12	16	(Note 1)
12.	POWER (KG)	1	1	2	4	12	12	(Note 1)
13.	RCVR OPERATE (KG)	1	2	2	4	12	16	(Note 1)
14.	XMTR ALARM (KG)	1	2	2	4	12	16	(Note 1)
15.	XMTR OPERATE (KG)	1	2	2	4	12	16	(Note 1)
16.	FRAME BIT MISCOMPARE	4	4	2	2	22	22	(Note 3)*

NOTES: (1) Available as front panel light. Requires Light Detector on front panel to utilize.

(2) Latches upon alarming. Pushbutton must be activated to unlatch. Usable only if latching circuitry is defeated.

(3) Requires internal circuit board modification and Tempest protection for access.

3.6.4 Final Monitor Point Selection Rationale

3.6.4.1 General

The preliminary list of monitored quantities outlined in Paragraph 3.6.3 was derived by considering the potential usefulness of each quantity individually, without the constraints of a monitoring systems approach or the benefit of a systems analysis to establish the systems level requirements and context. This section presents the rationale by which the final choices were guided.

3.6.4.2 Universal Considerations

The factors which entered into the final selection process are:

a. The most conclusive performance indicators should be used where alternatives exist. A conclusive indicator may be defined as one which is most closely related to the quality of the mission traffic.

   An example of the selection of a more conslusive indicator is the choice of partial response signal level over radio pilot level to indicate a change in radio system baseband to baseband gain. Changes in FM modulation and demodulation sensitivity will, in almost all likely situations, affect both levels in the same ratio. But, the baseband level is what directly affects the mission signal; the pilot level is presumptive. Therefore, baseband level was chosen.

b. Telemetry requirements should be reduced to a minimum, at least in a first level system. To do this, many "nice to know" parameters and alarms can either be eliminated or combined in a fashion which distills the available information into fewer quantities.

   The principal victim of this distillation is the maintenance man who must travel to a remote site. The more information available to him before starting his journey, the more confidence he has in having the correct spares, tools, and test equipment. However, in a sparse, frugal implementation, fault isolation beyond the equipment level is a nicety, which can always be added if the necessity is felt to be sufficiently strong.

c. Monitoring points should be selected in the context of the likelihood that the quantities observed will, in fact, degrade to a point affecting system operation, and not to provide a sense of completeness or logical symmetry. Every monitored point requires money, hardware and software, and is one more thing for system operators to comprehend and apprehend.

In approaching this criteria of monitor points selection, a viewpoint similar to the marginal utility theories of economics is appropriate. Loosely paraphrased, the system synthesist's corollary of these theories is: Given a hypothesized base which will do the job, is the incremental increase in usefulness of another feature worth the penalties of providing it?

An example of monitor points which vanish when these criteria are applied is activity monitors on digital data lines. Logical symmetry and completeness militate for their use. But, when the question is asked, "What is gained by adding these to the system?, the answer is "Whether or not a certain few transistors and wire pairs have failed." Since these are not stressed elements, and since gross failures are detected by other means, this degree of localization fails the marginal utility test.

d. A final, supercritical examination of the availability of each parameter is required. This is required, not in the context of the design engineer, to whom the insertion of test probes, scope leads, etc., is a way of life. Rather, it must be with the realization that changes to military equipment entail specific engineering of the change; change instructions and parts, record keeping; changes to documentation, and possible manufacturer's warranty problems. The implications of this viewpoint are to avoid altering the monitored equipment unless it is the only available means of obtaining a sizable increase in monitoring effectiveness.

With these general criteria in mind, the preliminary list of monitored quantities was matched to the general set of monitoring system objectives formulated in the preliminary system analysis.

3.6.4.3 Fault Detection and Isolation Processes

The temporal objectives for fault detection, developed in Paragraph 2.2, are to detect a service failure within 30 seconds; detect a loss of redundant back-up in five minutes, and detect a degradation of performance within 30 minutes.

Physically, the primary objective is to ultimately be capable of isolating problems to an equipment or path. However, this precision of isolation is not required simultaneously with detection of service failure.

a. Detection of Service Failures (30 seconds time objective) A service failure is the only condition which must be brought rapidly to the attention of transmission systems control personnel.

Where redundant equipments are provided, a service failure implies that both of the redundant elements are unserviceable. Geographical isolation is required to the link level, so that an immediate determination may be made of the operational effects and of the starting point for further problem analysis.

b. Detection of Loss of Redundancy (five minute temporal objective). The objectives in detection of loss of redundancy are to determine that a standby equipment has failed and to pinpoint which equipment at which site. This is sufficient to point a maintenance man with the necessary specialty in the right direction. Information beyond that degree of detail is nice to know, but not necessary to fulfill the primary objective of isolating failures to the offending equipment.

c. Detection of Degradation (30 minute temporal objective). In the context of the 30-minute limit for detection of degradation is meant the type of degradation which is steady-state, and obvious. Degradation which manifests itself through more subtle or evanescent effects will often require long periods of observation to become evident.

A multiplicity of potential monitoring points for measuring degradation exists within the system, and is cataloged in the candidate monitor point list. A second pass, eliminating obvious redundancies, resulted in the preliminary list. The final analysis in the light of system requirements has produced an even more frugal set of parameters.

3.6.4.4 Performance Assessment and Performance Margin Indicators

In Paragraph 2.1.2, the parameters that are required for CPMAS of the FKV are discussed. These parameters are availability, bit error rate; percentage of error-free intervals, bit count integrity; equivalent PCM noise, and performance margin.

Another factor discussed in Paragraph 2.4, entering into the final selection of sources of PA and PMA information is the need of network control to know network performance on a link-by-link basis as well as on an end-for-end basis.

Thus in the final review of monitoring points, the following criteria were added to the general criteria discussed previously:

a. Does the monitored quantity, either by itself or in combination with others, contribute to providing a measure, direct or indirect, of the system performance parameters?

b. Does the set of points selected contribute to the system control organization's need to assess performance and margin on a link-by-link, as well as end-to-end basis?

3.6.4.5 Out-of-Service Indicators

One of the obvious potential problems of a monitoring system is that of generating false alarms and incorrect performance indications for equipment which has been deliberately removed from service for maintenance. To obviate this problem, a set of switches is recommended at each site, which, via the alarm scanning system, notify the central site personnel and processor that an equipment is in a maintenance status.

3.7 RECOMMENDED FKV MONITOR POINTS

3.7.1 AN/FRC-162 Radio

Table 3-18 presents the final list of FKV radio monitor points. As shown, the Tx Problem alarms are the OR function of Tx Power, Tx AFC and Tx Pilot alarms. The Rx Problem alarms are the OR function of Rx Phaselock and Rx Squelch alarms. Radio Rx, a sudden service failure sensing system input, is the AND function of Rx Pilot A and Rx Pilot B. Occurrence of the Radio Rx alarm implies total loss of the radio link. The Maintenance alarms are operator-initiated contact closures which indicate that maintenance is in progress on a particular unit. Analog power supply voltages have been included on an optional basis. By consolidating alarms, the original recommended monitor point list, Paragraph 3.6.3, has been reduced.

Deleted monitor points are discussed in Paragraph 3.8.

Rationale for the consolidation of alarms, as discussed above, was the ability to reduce the number of alarms collected without a corresponding reduction in system usefulness. For example, it is *not* important from the maintenance viewpoint to know specifically which transmitter alarm occurred and, hence, why a particular transmitter is inoperative. Rather, the usefulness is limited to the knowledge that some major transmitter alarm has occurred and that the corresponding transmitter is inoperative. A similar argument may be applied in the case of the consolidated receiver alarms in which case it is important to

know than an alarm internal to the receiver has occurred and that the receiver is (probably) inoperative.

The Radio Rx alarm was added to satisfy the sudden service failure sensing system requirements. This alarm occurs if both receivers are inoperative.

Maintenance status indicators were added so that the performance monitoring system may be made aware of maintenance in progress on an equipment and take appropriate action in the case of alarms occurring due to this activity.

Optional power supply monitor points were added to permit the possible detection of impending failures due to power supply failure.

TABLE 3-18. RADIO MONITOR POINT LIST

Tx Problem A (Power + AFC + Pilot)	RSL A (Previously called AGC A)
Tx Problem B (Power + AFC + Pilot)	RSL B (Previously called AGC B)
Rx Problem A (Rx Phaselock + Rx Squelch)	Maintenance A
	Maintenance B
Rx Problem B (Rx Phaselock + Rx Squelch)	Tx In-Service
Rx Squelch A	Rx In-Service
Rx Squelch B	PS Voltages 1 through 8*
Radio Rx (Rx Pilot A ● Rx Pilot B)	

----

* Optional ● Denotes AND + Denotes OR

3.7.2 T1-4000 Multiplexer

Table 3-19 presents the final list of FKV high-level multiplexer monitor points.

Maintenance-Normal and Standby serve the same function and were included for the same reason preivously stated above. Similarly, power supply monitor points have been included for reasons previously mentioned. Control Reframe-Normal and Standby was added because investigation revealed control reframe to be a more sensitive indicator of a potential problem than main reframe and consequently a more useful monitor point.

TABLE 3-19. T1-4000 MONITOR POINT LIST

Switch Major	Main Frame Bit Error Normal
Switch Minor	Main Frame Bit Error Standby
Major - Normal	Control Reframe Normal
Major - Standby	Control Reframe Standby
Maintenance - Normal	Tx In-Service (Status indicator)
Maintenance - Standby	Rx In-Service (Status indicator)
	PS Voltages 1 through 5*

* Optional

3.7.3 Baseband Monitor Point List

A new monitor point location classification is shown as Table 3-20.

TABLE 3-20. BASEBAND MONITOR POINT LIST

Eye-Radio A	Eye-RAdio B
Noise	Noise
Amplitude	Amplitude
Bursts	Bursts

Parameters measured here are derived from the baseband signal at the radio receiver outputs. These are the analog signals from the radio receiver outputs to the diversity switch to the T1-4000 receiver input.

Briefly the baseband waveform is AGC'd and filtered to produce a 3-level signal eye scatter or noise and the burst character of the noise is converted to analog voltages which are measured by a MAC.

The eye scatter noise is related to multiplexer performance over a useful range of error rates and may be used to derive a measure of radio link performance margin.

Amplitude of the signal from the radio output is valuable for assessing operation of the multiplexer transmitter and radio link and also is useful for fault isolating to the level of the T1-4000 receiver. For example, if the eye pattern monitor is integral to the multiplexer, given a poor eye and poor multiplexer performance, one cannot distinguish between a radio system or a multiplexer system problem. Indeed, the argument for monitoring the eye at a location between the radio and multiplexer need not be related to the monitoring of any parameter in particular.

A measure of the burstlike or hit nature of the noise is also made for the purpose of detecting radio frequency interference of an impulse or burst nature. Inclusion of the burst measurement in the baseband monitor effectively removes the requirement for a radio noise burst measurement.

3.7.4 T1WB1 Submultiplexer

The final T1WB1 low-level multiplexer monitor point list is given in Table 3-21, An operator-initiated maintenance status indicator has been included for reasons mentioned above. Similarly, the optional collection of power supply voltages is included.

TABLE 3-21. T1WB1 MONITOR POINT LIST

Office	Frame Bit Error
Reframe	
Maintenance	PS Voltages 1 through 6*

*Optional

3.7.5 CY-104 PCM/TDM

The final CY-104 monitor point list, shown in Table 3-22 includes only the Service Alarm and Remote Alarms from the original recommended candidate monitor points.

TABLE 3-22. CY-104 MONITOR POINT LIST

Service Alarm

Remote Alarm

3.7.6 VF Monitor Parameters

VF channel parameters are determined by means of IQCS measurements and are; AV = average power in dBm and, FN = flat noise, unweighted, 2600 Hz notch in dBm. The primary reason for performing VF measurements is verification of system operation given that all other status indicators show that the system is operational. Making these baseband measurements also permits the operator or tech controller to determine if a known VF degradation has arisen within or external to the FKV system.

3.7.7 Site-Related Monitor Points

Status indicating monitor points as a function of location within the FKV are summarized in Table 3-23. This list is identical to that recommended in the FKV System Engineering Plan, Volume I; FKV Project; August 30, 1974, as site monitoring points for the FASR system. The list should be regarded as semifinal since it may be improved upon only after actual site inspections.

TABLE 3-23. SITE MONITOR POINT LIST

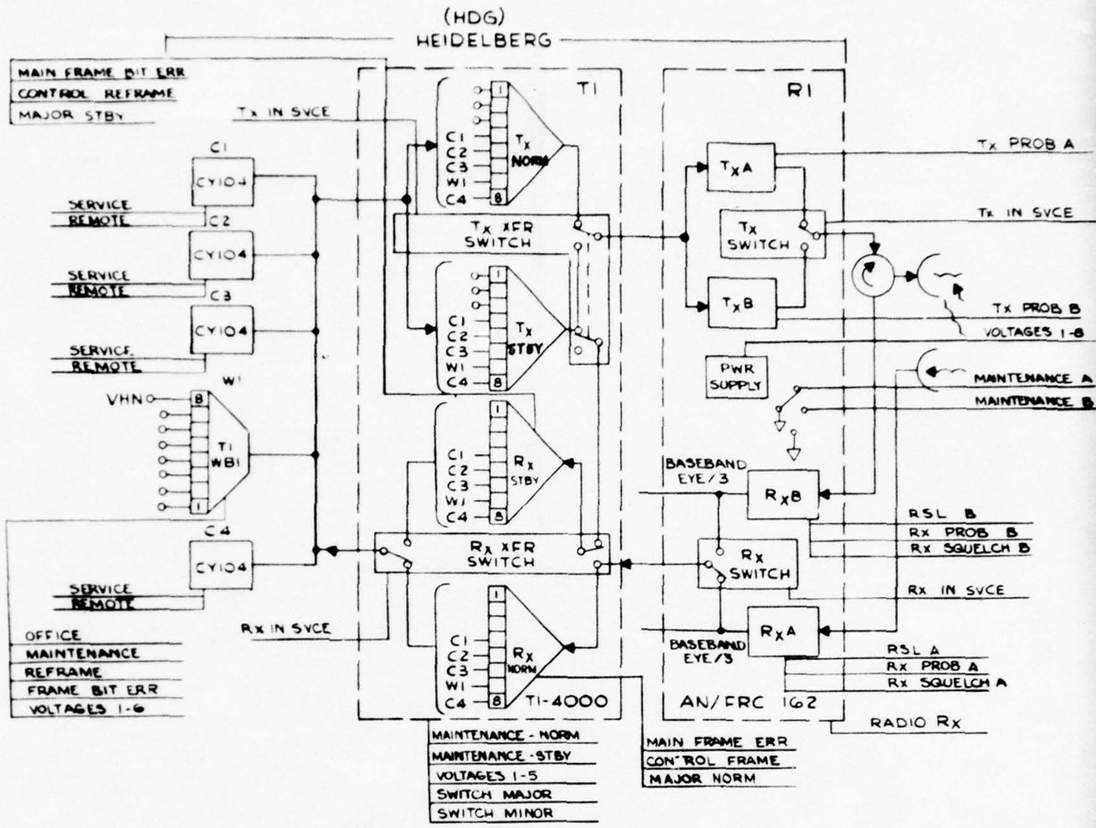
	HDG	SWN	KSL	STB	SGT	VHN
Illegal Entry		X		X		
Fire: Generator		X		X		
Fire: Building		X		X		
Water Flood		X		X		
Fuel Level		X		X		
DC/AC Inverter			X		X	
Wave Guide Pressure	X	X	X	X	X	X
Wave Guide Humidity	X	X	X	X	X	X
Tower Lights		X	X	X		X
AC Power	X	X	X	X	X	X
Battery Charger	X	X	X	X	X	X
Battery Status	X	X	X	X	X	X

3.7.6 Site Drawings

FKV site drawings which detail proposed monitor points for the performance monitoring system are given in Figures 3-8 through 3-13.

Generally all alarms and status indicators are picked up by an alarm scanner. However, in the situation in which another scanner would be required to serve only a few status indicators, these indicators are serviced as two-valued analog signals and picked up by an alarm scanner. Such is the case at KSL, where the analog scanner services four of the site status indicators. Since alarm scanner input increments occur in multiples of 10, often spare inputs are available as indicated.

All analog voltages are monitored by means of analog scanners. At KSL and SGT, two analog scanners are required even though the total number of analog parameters for the site is less than the 100 which normally is accessed by a full analog scanner. This is due to the fact that one EPUT meter card physically replaces one analog scanner card or 10 analog inputs are rendered unavailable. One EPUT card per parameter counted is required. Additionally, for each group of EPUT cards at a particular site, one master timing card is required. Thus, for example, if four things are counted at a site, 5 card slots in the analog scanner are required for the 4 counter cards and 1 clock card.



ALARM SCANNER NO.1 (40 ALARMS)

R_x SQUELCH A/R1	• OFFICE/W1
R_x PROBLEM A/R1	MAINTENANCE/W1
R_x SQUELCH B/R1	R_x IN SERVICE/R1
R_x PROBLEM B/R1	T_x IN SERVICE/R1
• RADIO R_x	R_x IN SERVICE/T1
MAINTENANCE A/R1	T_x IN SERVICE/T1
MAINTENANCE B/R1	SPARE
T_x PROBLEM A/R1	
T_x PROBLEM B/R1	
MAJOR NORM/T1	
MAJOR STBY/T1	
• SWITCH MAJOR/T1	
SWITCH MINOR/T1	BATTERY CHARGER
MAINTENANCE NORM/T1	W.G. PRESSURE
MAINTENANCE STBY/T1	W.G. HUMIDITY
• SERVICE/C1	A.C. POWER
REMOTE/C1	BATTERY STATUS
• SERVICE/C2	• SITE
REMOTE/C2	SPARE
• SERVICE/C3	SPARE
REMOTE/C3	SPARE
• SERVICE/C4	SPARE
REMOTE/C4	• SUDDEN SERVICE FAILURE SENSING SYSTEM

ANALOG SCANNER NO.1 (40 PARAMETERS)

RSL A/R1		* VOLTAGE 1/R1
RSL B/R1		* VOLTAGE 2/R1
EYE A-1/R1	BASEBAND MONITOR	* VOLTAGE 3/R1
EYE A-2/R1		* VOLTAGE 4/R1
EYE A-3/R1		* VOLTAGE 5/R1
EYE B-1/R1	PARAMETERS MEASURED BY BASEBAND MONITOR	* VOLTAGE 6/R1
EYE B-2/R1		* VOLTAGE 7/R1
EYE B-3/R1		* VOLTAGE 8/R1
MAIN FRAME BIT ERR NORM/T1		* VOLTAGE 1/T1
CONTROL REFRAME NORM/T1		* VOLTAGE 2/T1
MAIN FRAME BIT ERR STBY/T1		* VOLTAGE 3/T1
CONTROL REFRAME STBY/T1		* VOLTAGE 4/T1
R_x IN SERVICE/R1		* VOLTAGE 5/T1
R_x SQUELCH A/R1		* VOLTAGE 1/W1
R_x SQUELCH B/R1		* VOLTAGE 2/W1
R_x IN SERVICE/T1		* VOLTAGE 3/W1
FRAME BIT ERR/W1		* VOLTAGE 4/W1
REFRAME/W1		* VOLTAGE 5/W1
		* VOLTAGE 6/W1
		SPARE
		SPARE
		SPARE
		SPARE
		SPARE
		SPARE

BUILDIN

BATT
W.G.
W.G.
A.C.
BATT
SITE

BASEBAND
EYE
EYE
EYE

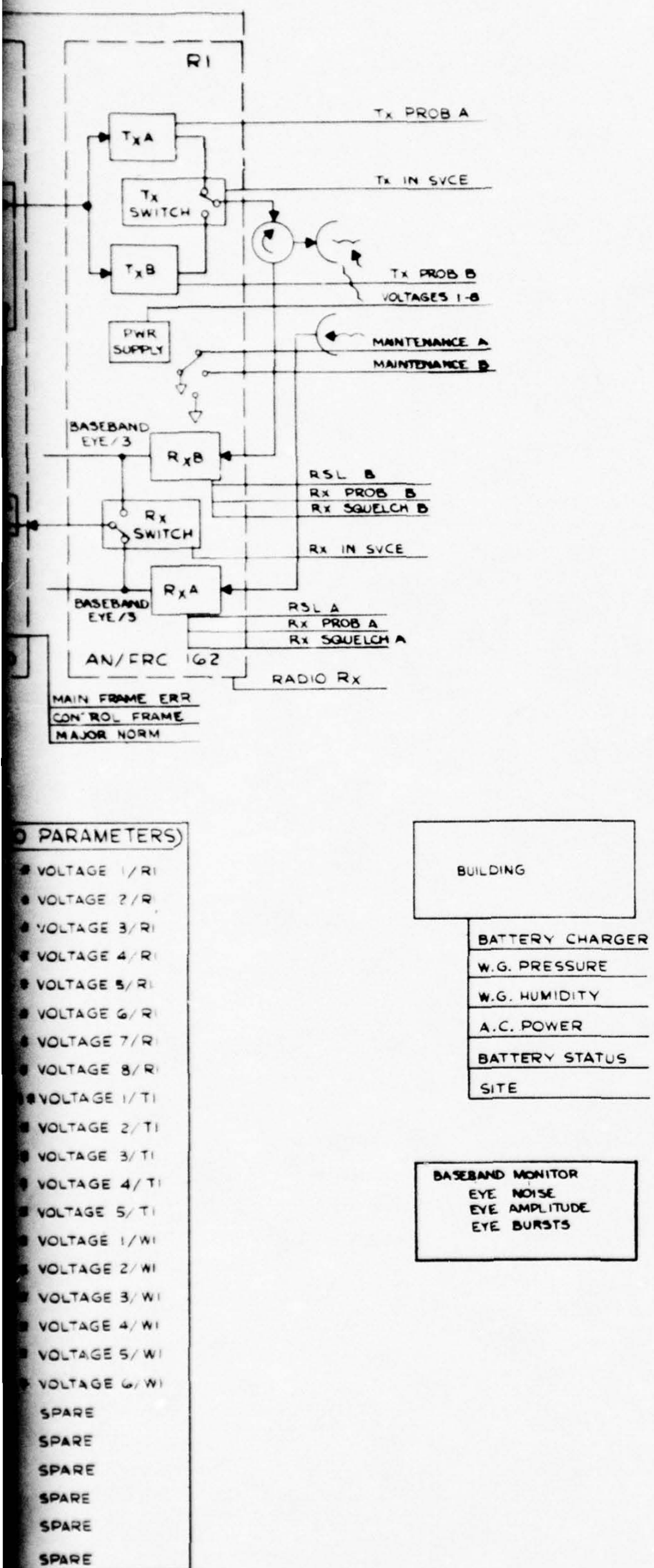
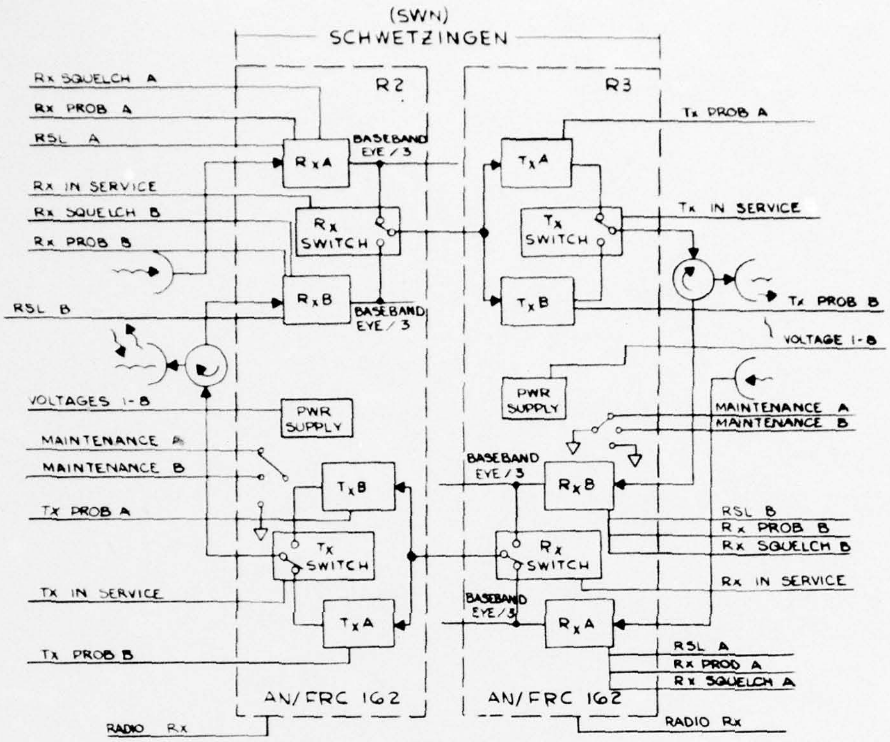


FIGURE 3-8. ALARM/PARAMETER MONITOR POINT LIST HEIDELBERG



ALARM SCANNER NO 2
(40 ALARMS)

Rx SQUELCH A/R2
Rx PROBLEM A/R2
Rx SQUELCH B/R2
Rx PROBLEM B/R2
• RADIO Rx/R2
MAINTENANCE A/R2
MAINTENANCE B/R2
Tx PROBLEM A/R2
Tx PROBLEM B/R2
Rx SQUELCH A/R3
Rx PROBLEM A/R3
Rx SQUELCH B/R3
Rx PROBLEM B/R3
• RADIO Rx/R3
MAINTENANCE A/R3
MAINTENANCE B/R3
Tx PROBLEM A/R3
Tx PROBLEM B/R3
Rx IN SERVICE/R2
Tx IN SERVICE/R2
Rx IN SERVICE/R3
Tx IN SERVICE/R3
BATTERY CHARGER
ILLEGAL ENTRY
FIRE: GENERATOR
FIRE: BUILDING
WATER FLOOD
FUEL LEVEL
W.G. PRESSURE
W.G. HUMIDITY
TOWER LIGHTS
A.C. POWER
BATTERY STATUS
• SITE
SPARE
SPARE
SPARE
SPARE
SPARE
SPARE

• SUDDEN SERVICE FAILURE SENSING SYSTEM

ANALOG SCANNER NO 2
(30 PARAMETERS)

RSL A/R2
RSL B/R2
EYE A-1/R2
EYE A-2/R2
EYE A-3/R2
EYE B-1/R2
EYE B-2/R2
EYE B-3/R2
Rx IN SERVICE/R2
Rx SQUELCH A/R2
Rx SQUELCH B/R2
RSL A/R3
RSL B/R3
EYE A-1/R3
EYE A-2/R3
EYE A-3/R3
EYE B-1/R3
EYE B-2/R3
EYE B-3/R3
Rx IN SERVICE/R3
Rx SQUELCH A/R3
Rx SQUELCH B/R3
VOLTAGE 1/R2
VOLTAGE 2/R2
VOLTAGE 3/R2
VOLTAGE 4/R2
VOLTAGE 5/R2
VOLTAGE 6/R2
VOLTAGE 7/R2
VOLTAGE 8/R2
VOLTAGE 1/R3
VOLTAGE 2/R3
VOLTAGE 3/R3
VOLTAGE 4/R3
VOLTAGE 5/R3
VOLTAGE 6/R3
VOLTAGE 7/R3
VOLTAGE 8/R3
SPARE

* OPTIONAL

BUILDING

BATTERY CHARGER
ILLEGAL ENTRY
FIRE: GENERATOR
FIRE: BUILDING
WATER FLOOD
FUEL LEVEL
W.G. PRESSURE
W.G. HUMIDITY
TOWER LIGHTS
A.C. POWER
BATTERY STATUS
SITE

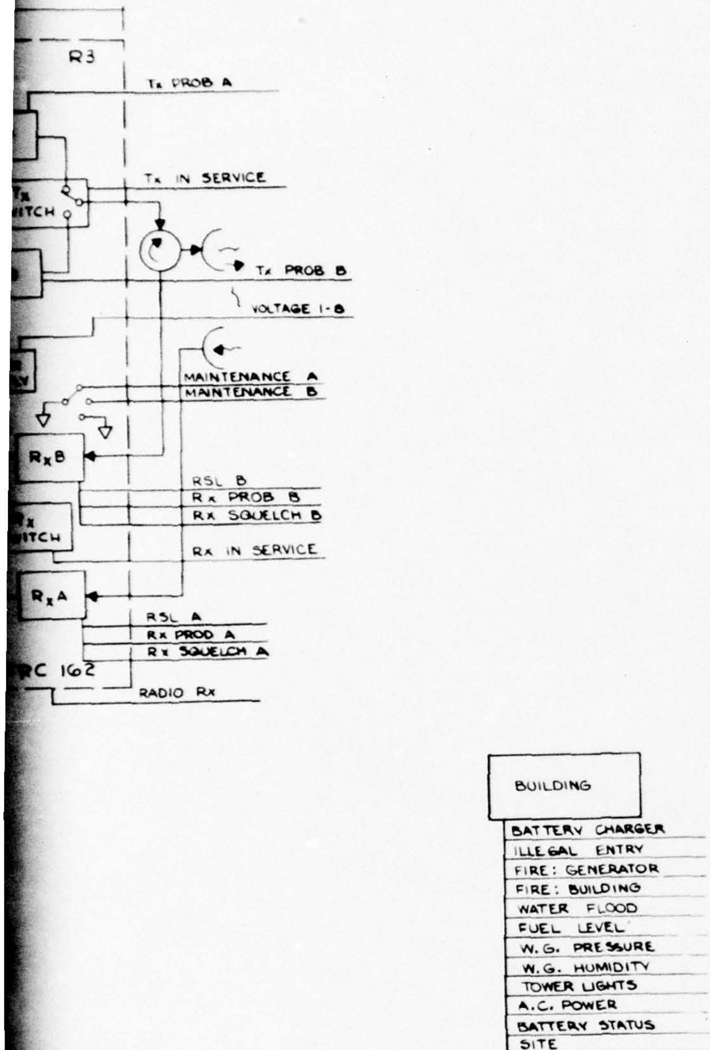
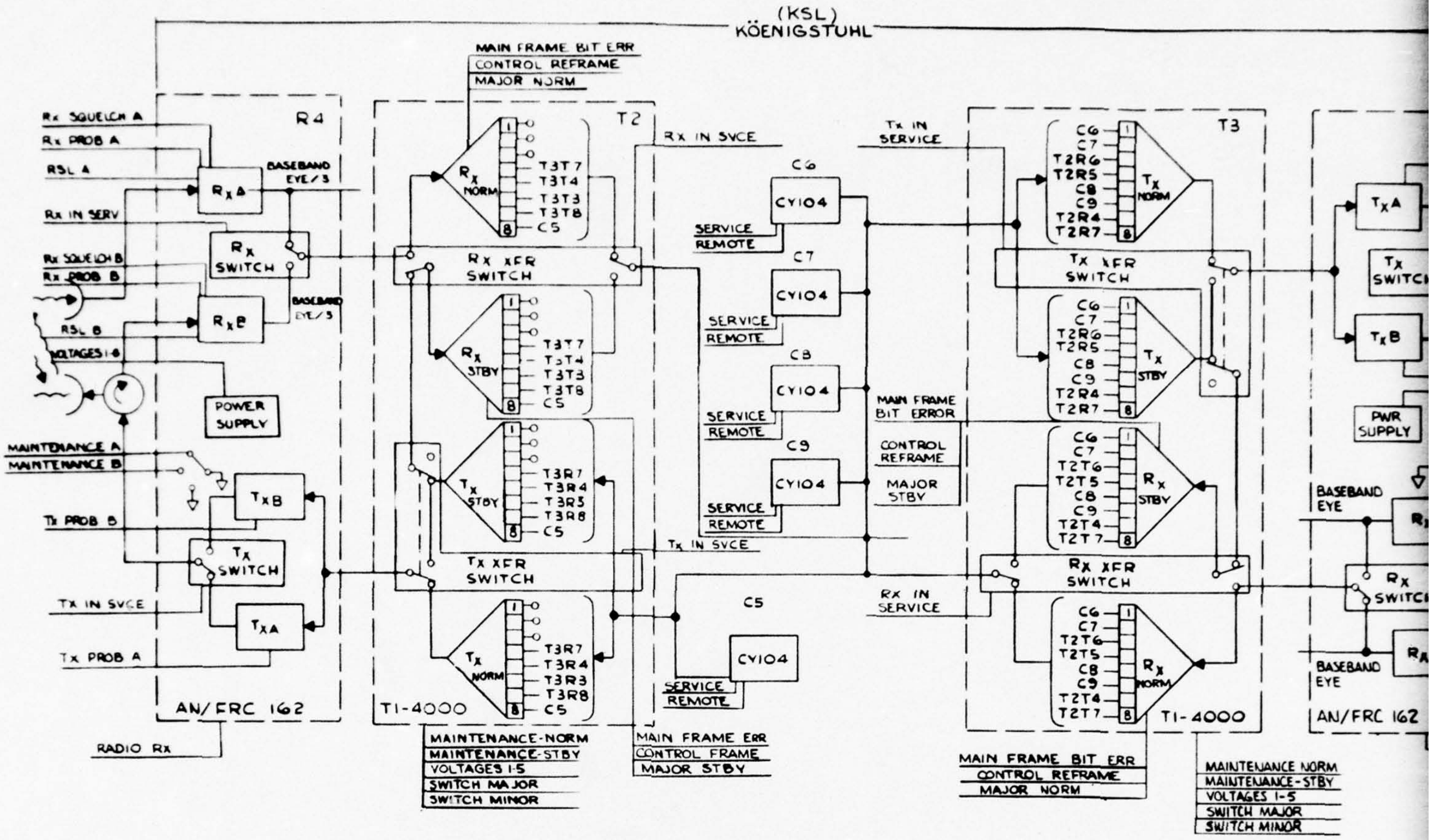


FIGURE 3-9. ALARM/PARAMETER MONITOR POINT LIST SCHWETZINGEN



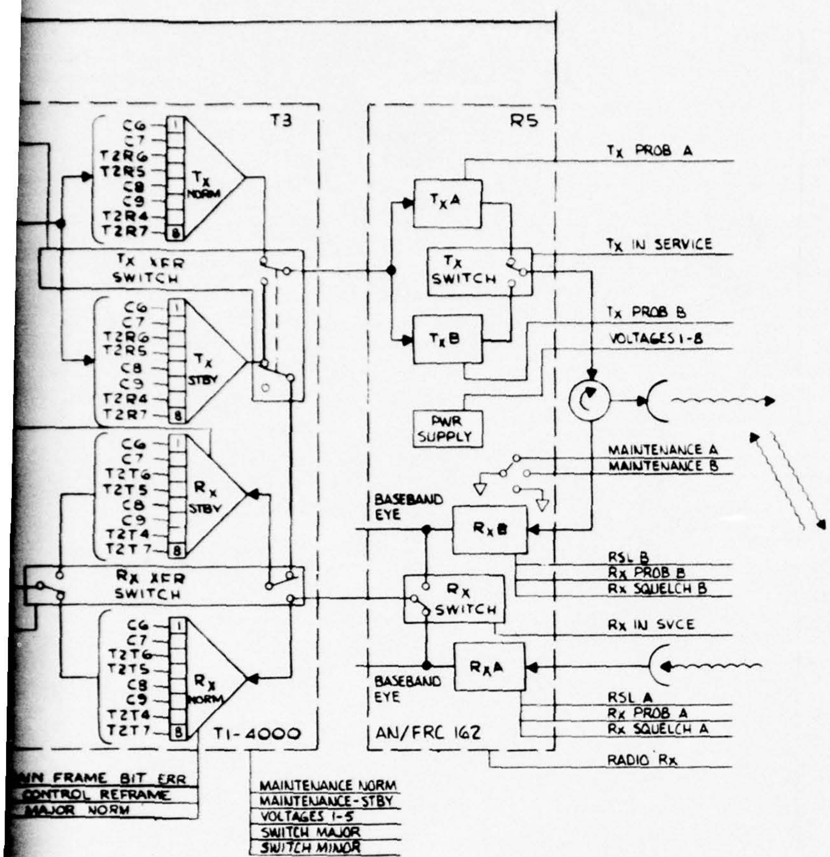
ALARM SCANNER NO. 3 (50 ALARMS)

R_x SQUELCH A/R4	● SERVICE /C9	BATTERY CHARGER
R_x PROBLEM A/R4	REMOTE /C9	DC/AC INVERTER
R_x SQUELCH B/R4	MAJOR STBY /T3	BATTERY STATUS
R_x PROBLEM B/R4	MAJOR NORM /T3	● SITE
● RADIO R_x /R4	● SWITCH MAJOR /T3	
MAINTENANCE A/R4	SWITCH MINOR /T3	
MAINTENANCE B/R4	MAINTENANCE NORM /T3	
T_x PROBLEM A/R4	MAINTENANCE STBY /T3	
T_x PROBLEM B/R4	R_x SQUELCH B/R5	
MAJOR NORM /T2	R_x PROBLEM B/R5	
MAJOR STBY /T2	R_x SQUELCH A/R5	
● SWITCH MAJOR /T2	R_x PROBLEM A/R5	
SWITCH MINOR /T2	● RADIO R_x /R5	
MAINTENANCE NORM /T2	MAINTENANCE A/R5	
MAINTENANCE STBY /T2	MAINTENANCE B/R5	
● SERVICE /C5	R_x IN SERVICE /T4	
REMOTE /C5	T_x IN SERVICE /T4	
● SERVICE /C6	R_x IN SERVICE /T2	
REMOTE /C6	T_x IN SERVICE /T2	
● SERVICE /C7	R_x IN SERVICE /R3	
REMOTE /C7	T_x IN SERVICE /R3	
● SERVICE /C8	R_x IN SERVICE /R5	
REMOTE /C8	T_x IN SERVICE /R5	

● SUDDEN SERVICE FAILURE SENSING SYSTEM

ANALOG SCANNER NO. 3 & 4 (60 P

RSL A/R4		MAIN FRAME BIT ERR
RSL B/R4		CONTROL REFRAME ST
EYE A-1/R4	BASEBAND MONITOR	R_x IN SERVICE/R5
EYE A-2/R4		R_x SQUELCH A/R5
EYE A-3/R4		R_x SQUELCH B/R5
EYE B-1/R4	PARAMETERS MEASURED BY MULTIPLEXING BASEBAND MONITOR	R_x IN SERVICE/T3
EYE B-2/R4		● VOLTAGE 1/R4
EYE B-3/R4		● VOLTAGE 2/R4
MAIN FRAME BIT ERR NORM/T2		● VOLTAGE 3/R4
CONTROL REFRAME NORM/T2		● VOLTAGE 4/R4
MAIN FRAME BIT ERR STBY/T2		● VOLTAGE 5/R4
CONTROL REFRAME STBY/T2		● VOLTAGE 6/R4
R_x IN SERVICE/R4		● VOLTAGE 7/R4
R_x SQUELCH A/R4		● VOLTAGE 8/R4
R_x SQUELCH B/R4		● VOLTAGE 1/T2
R_x IN SERVICE/T2		● VOLTAGE 2/T2
RSL A/R5		● VOLTAGE 3/T2
RSL B/R5		● VOLTAGE 4/T2
EYE A-1/R5	PARAMETERS MEASURED BY MULTIPLEXING BASEBAND MONITOR	● VOLTAGE 5/T2
EYE A-2/R5		● VOLTAGE 1/T3
EYE A-3/R5		● VOLTAGE 2/T3
EYE B-1/R5	PARAMETERS MEASURED BY MULTIPLEXING BASEBAND MONITOR	● VOLTAGE 3/T3
EYE B-2/R5		● VOLTAGE 4/T3
EYE B-3/R5		● VOLTAGE 5/T3
MAIN FRAME BIT ERR NORM/T3		● VOLTAGE 1/R5
CONTROL REFRAME NORM/T3		● VOLTAGE 2/R5



ANALOG SCANNER NO. 3 & 4 (60 PARAMETERS)

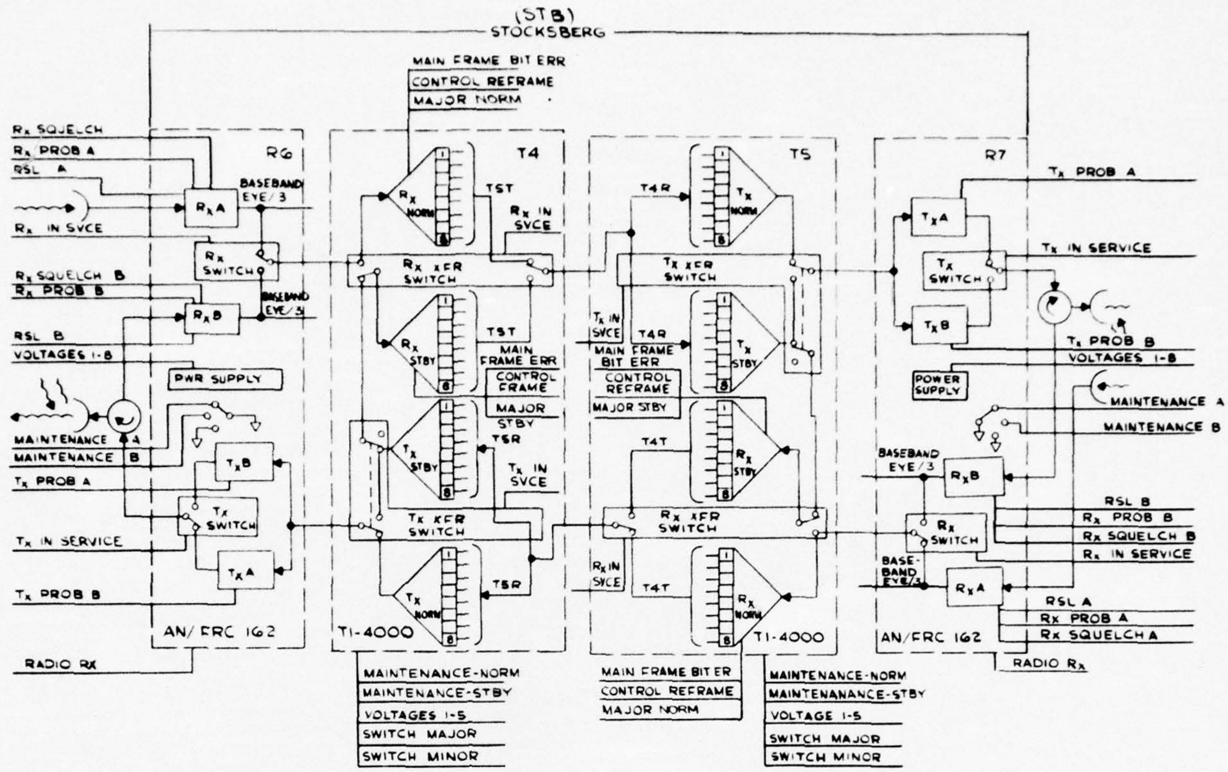
R4	MAIN FRAME BIT ERR STBY/T3	* VOLTAGE 3/R5
R4	CONTROL REFRAME STBY/T3	* VOLTAGE 4/R5
/R4 BASEBAND MONITOR	Rx IN SERVICE/R5	* VOLTAGE 5/R5
/R4	Rx SQUELCH A/R5	* VOLTAGE 6/R5
/R4	Rx SQUELCH B/R5	* VOLTAGE 7/R5
/R4 PARAMETERS MEASURED BY MULTIPLEXING BASEBAND MONITOR	Rx IN SERVICE/T3	* VOLTAGE 8/R5
/R4	* VOLTAGE 1/R4	W.G. PRESSURE
/R4	* VOLTAGE 2/R4	W.G. HUMIDITY
ME BIT ERR NORM/T2	* VOLTAGE 3/R4	TOWER LIGHTS
REFRAME NORM/T2	* VOLTAGE 4/R4	A.C. POWER
ME BIT ERR STBY/T2	* VOLTAGE 5/R4	SPARE
REFRAME STBY/T2	* VOLTAGE 6/R4	SPARE
RVICE/R4	* VOLTAGE 7/R4	SPARE
LCH A/R4	* VOLTAGE 8/R4	SPARE
LCH B/R4	* VOLTAGE 1/T2	SPARE
RVICE/T2	* VOLTAGE 2/T2	SPARE
R5	* VOLTAGE 3/T2	SPARE
R5	* VOLTAGE 4/T2	
/R5 PARAMETERS MEASURED BY MULTIPLEXING BASEBAND MONITOR	* VOLTAGE 6/T2	
/R5	* VOLTAGE 1/T3	
/R5	* VOLTAGE 2/T3	
/R5 PARAMETERS MEASURED BY MULTIPLEXING BASEBAND MONITOR	* VOLTAGE 3/T3	*OPTIONAL
/R5	* VOLTAGE 4/T3	
/R5	* VOLTAGE 5/T3	
AME BIT ERR NORM/T3	* VOLTAGE 1/R5	
REFRAME NORM/T3	* VOLTAGE 2/R5	

BUILDING

- BATTERY CHARGER
- DC/AC INVERTER
- W.G. PRESSURE
- W.G. HUMIDITY
- TOWER LIGHTS
- A.C. POWER
- BATTERY STATUS
- SITE

BASEBAND MONITOR
EYE NOISE
EYE AMPLITUDE
EYE BURSTS

FIGURE 3-10. ALARM/PARAMETER MONITOR POINT LIST KOENIGSTUHL



ALARM SCANNER NO 4 (50 ALARMS)

Rx SQUELCH A / R6
Rx PROBLEM A / R6
Rx SQUELCH B / R6
Rx PROBLEM B / R6
• RADIO Rx / R6
MAINTENANCE A / R6
MAINTENANCE B / R6
Tx PROBLEM A / R6
Tx PROBLEM B / R6
MAJOR NORM / T4
MAJOR STBY / T4
• SWITCH MAJOR / T4
SWITCH MINOR / T4
MAINTENANCE NORM / T4
MAINTENANCE STBY / T4
Rx SQUELCH A / R7
Rx PROBLEM A / R7
Rx SQUELCH B / R7
Rx PROBLEM B / R7
• RADIO Rx / R7
MAINTENANCE A / R7
MAINTENANCE B / R7
Tx PROBLEM A / R7
Tx PROBLEM B / R7
MAJOR NORM / T5
MAJOR STBY / T5
• SWITCH MAJOR / T5
SWITCH MINOR / T5
MAINTENANCE NORM / T5
MAINTENANCE STBY / T5
Rx IN SERVICE / R6
Tx IN SERVICE / R6
Rx IN SERVICE / T4
Tx IN SERVICE / T4
Rx IN SERVICE / R7
Tx IN SERVICE / R7
Rx IN SERVICE / T5
Tx IN SERVICE / T5

BATTERY CHARGER
ILLEGAL ENTRY
FIRE : GENERATOR
FIRE : BUILDING
WATER FLOOD
FUEL LEVEL
W.G. PRESSURE
W.G. HUMIDITY
TOWER LIGHTS
A.C. POWER
BATTERY STATUS
• SITE

• SUDDEN SERVICE FAILURE SENSING SYSTEM

ANALOG SCANNER NO 5&6 (50 PARAMETERS)

RSL A / R6
RSL B / R6
EYE A-1 / R6
EYE A-2 / R6 } BASEBAND MONITOR
EYE A-3 / R6
EYE B-1 / R6
EYE B-2 / R6 } PARAMETERS MEASURED BY MULTIPLEXING BASEBAND MONITOR
EYE B-3 / R6
MAIN FRAME BIT ERR NORM / T4
CONTROL REFRAME NORM / T4
MAIN FRAME BIT ERR STBY / T4
CONTROL REFRAME STBY / T4
Rx IN SERVICE R4
Rx SQUELCH A / R4
Rx SQUELCH B / R4
Rx IN SERVICE / T4
RSL A / R7
RSL B / R7
EYE A-1 / R7
EYE A-2 / R7 } PARAMETERS MEASURED BY MULTIPLEXING BASEBAND MONITOR
EYE A-3 / R7
EYE B-1 / R7
EYE B-2 / R7 } PARAMETERS MEASURED BY MULTIPLEXING BASEBAND MONITOR
EYE B-3 / R7
MAIN FRAME BIT ERR NORM / T5
CONTROL REFRAME NORM / T5
MAIN FRAME BIT ERR STBY / T5
CONTROL REFRAME STBY / T5
Rx IN SERVICE / R7
Rx SQUELCH A / R7
Rx SQUELCH B / R7
Rx IN SERVICE / T5
* VOLTAGE 1 / R6
* VOLTAGE 2 / R6
* VOLTAGE 3 / R6
* VOLTAGE 4 / R6
* VOLTAGE 5 / R6
* VOLTAGE 6 / R6
* VOLTAGE 7 / R6
* VOLTAGE 8 / R6

* VOLTAGE 1 / T4
* VOLTAGE 2 / T4
* VOLTAGE 3 / T4
* VOLTAGE 4 / T4
* VOLTAGE 5 / T4
* VOLTAGE 1 / R7
* VOLTAGE 2 / R7
* VOLTAGE 3 / R7
* VOLTAGE 4 / R7
* VOLTAGE 5 / R7
* VOLTAGE 6 / R7
* VOLTAGE 7 / R7
* VOLTAGE 8 / R7
* VOLTAGE 1 / T5
* VOLTAGE 2 / T5
* VOLTAGE 3 / T5
* VOLTAGE 4 / T5
* VOLTAGE 5 / T5
SPARE

* OPTIONAL

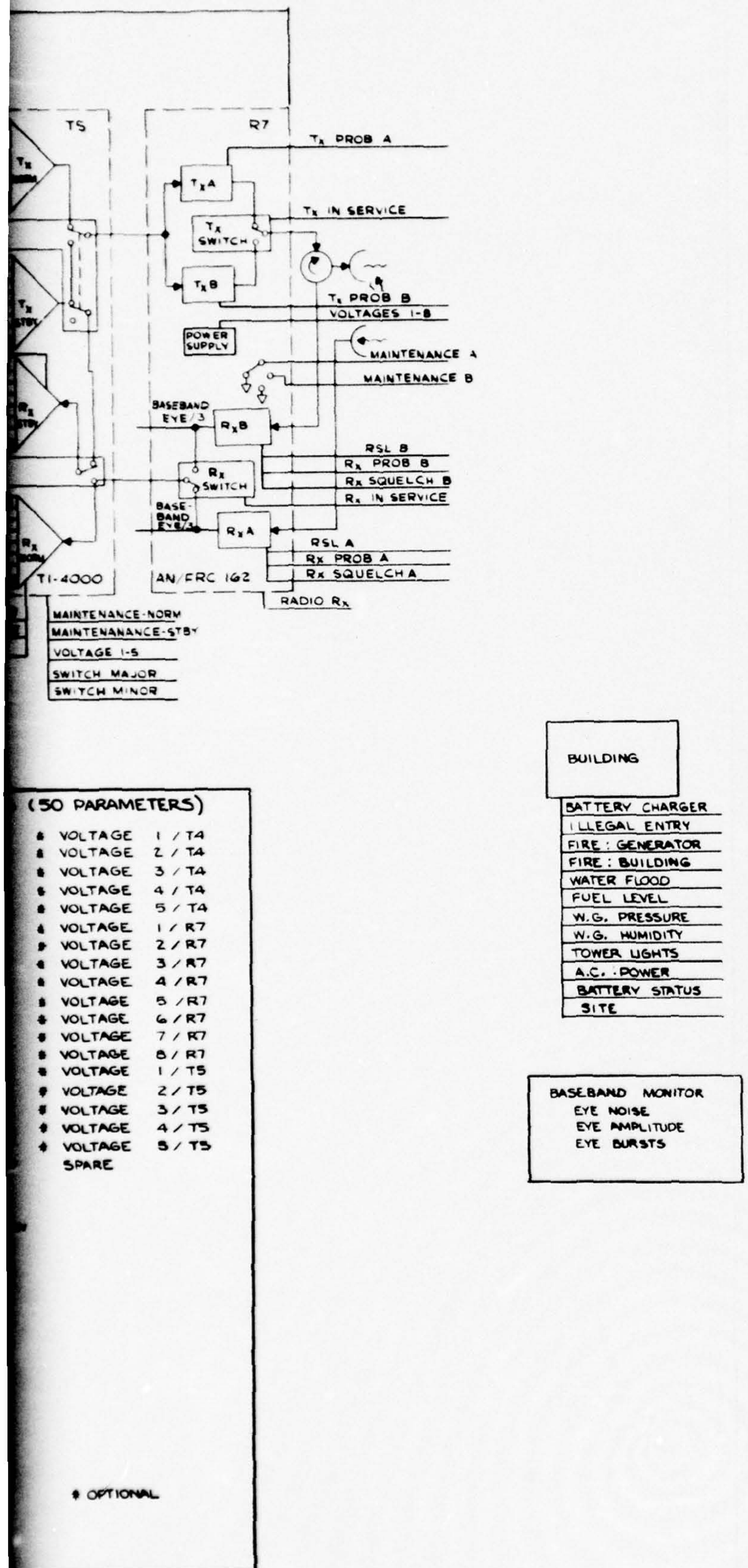
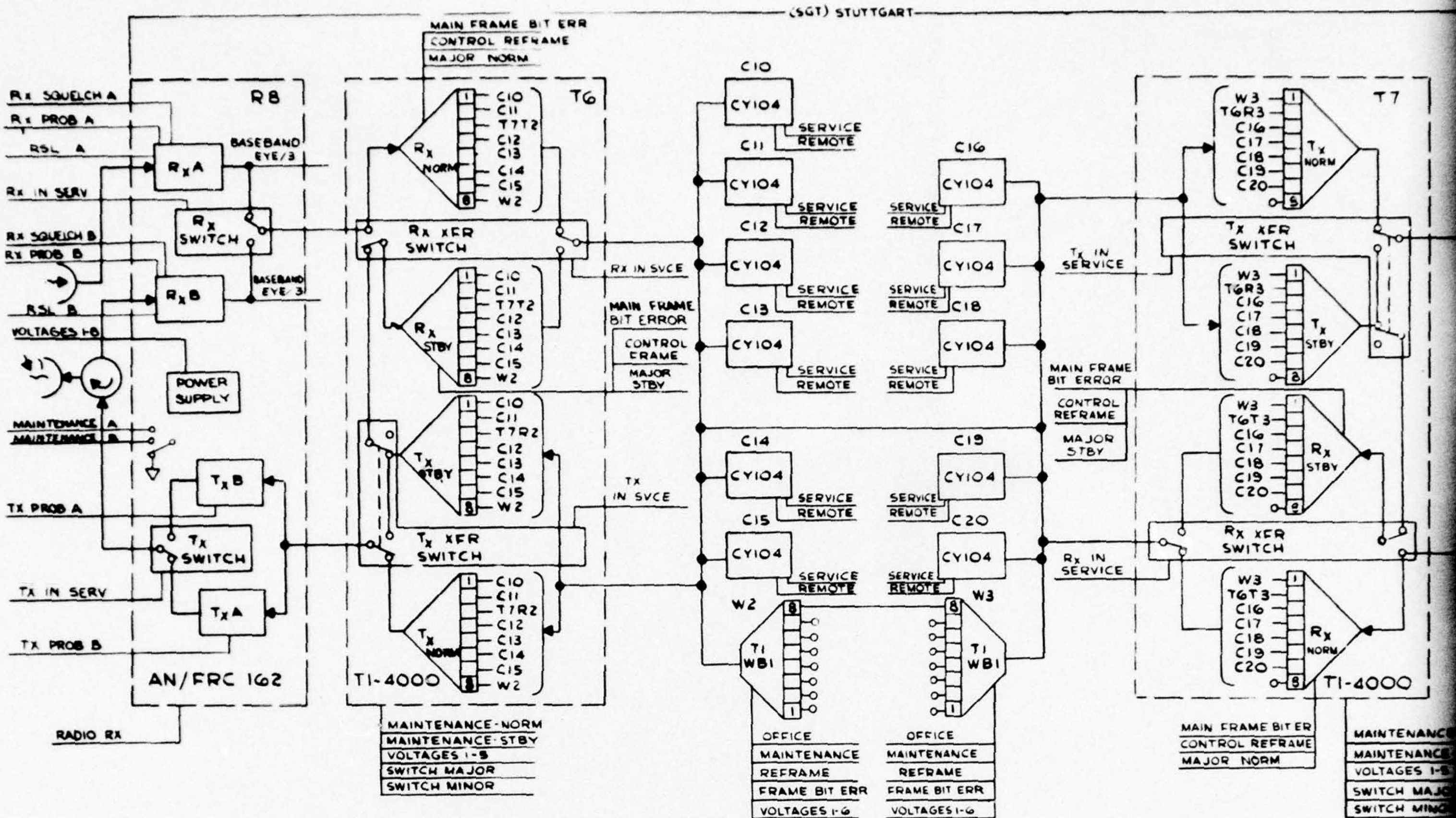


FIGURE 3-11. ALARM/PARAMETER MONITOR POINT LIST STOCKSBERG



ALARM SCANNER NO5 (50 ALARMS)

Rx SQUELCH A/R8
Rx PROB A/R8
Rx SQUELCH B/R8
Rx PROB B/R8
• RADIO Rx/R8
MAINTENANCE A/R8
MAINTENANCE B/R8
Tx PROB A/R8
Tx PROB B/R8

MAJOR-NORM/T6
MAJOR-STBY/T6
• SWITCH MAJOR/T6
SWITCH MINOR/T6
MAINTENANCE-NORM/T6
MAINTENANCE-STBY/T6
• SERVICE/C10
REMOTE/C10
• SERVICE/C11
REMOTE/C11
• SERVICE/C12
REMOTE/C12
• SERVICE/C13
REMOTE/C13
• SERVICE/C14
REMOTE/C14
• SERVICE/C15
REMOTE/C15
• OFFICE/W2
MAINTENANCE/W2
REFRAME/W2
• SERVICE/C16
REMOTE/C16
• SERVICE/C17
REMOTE/C17
• SERVICE/C18
REMOTE/C18
• SERVICE/C19
REMOTE/C19
• SERVICE/C20
REMOTE/C20
• OFFICE/W3
MAINTENANCE/W3
REFRAME/W3
MAJOR STBY/T7
MAJOR NORM/T7
• SWITCH MAJOR/T7
SWITCH MINOR/T7
Tx PROB A/R9
Tx PROB B/R9

Rx SQUELCH B/R9

• SUDDEN SERVICE FAILURE SENSING SYSTEM

ALARM SCANNER NO6 (30 ALARMS)

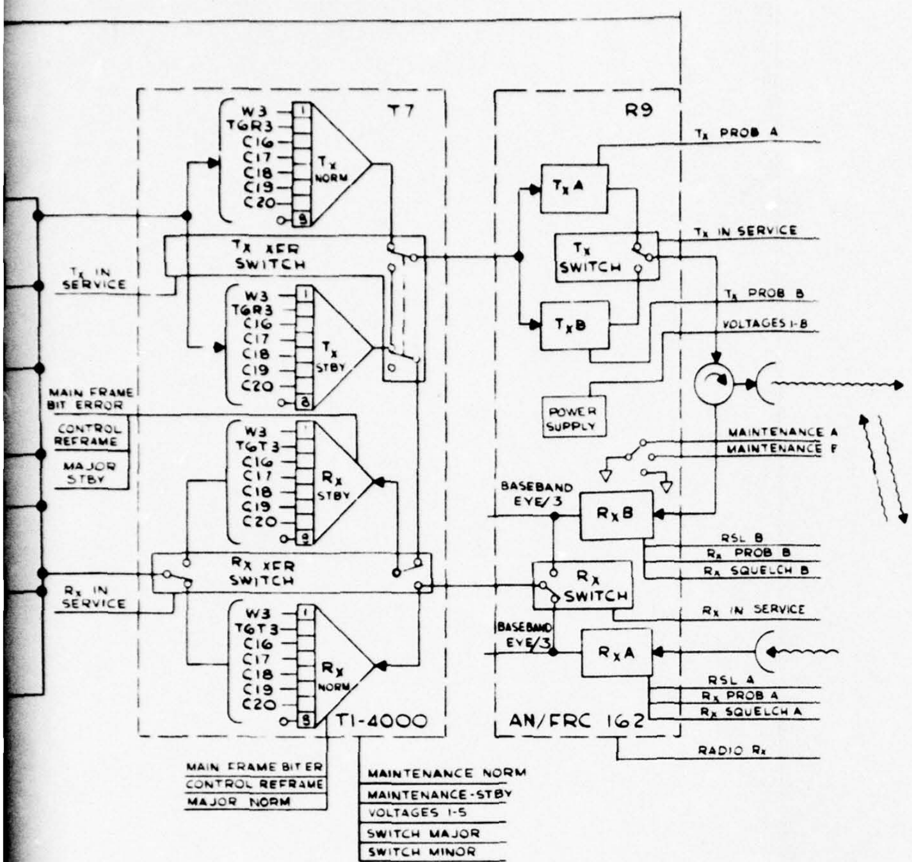
Rx IN SERV/R8
Tx IN SERV/R8
Rx IN SERV/T6
Tx IN SERV/T6
Tx IN SERV/T7
Rx IN SERV/T7
MAINTENANCE-NORM/T7
MAINTENANCE-STBY/T7
Tx IN SERV/R9
Rx IN SERV/R9
MAINTENANCE A/R9
MAINTENANCE B/R9
BATTERY CHARGER
DC/AC INVERTER
W.G. PRESSURE
W.G. HUMIDITY
AC POWER
BATTERY STATUS
• SITE
Rx PROB B/R9
Rx PROB A/R9
Rx SQUELCH A/R9
• RADIO Rx/R9
SPARE
SPARE
SPARE
SPARE
SPARE
SPARE
SPARE

• SUDDEN SERVICE FAILURE SENSING SYSTEM

ANALOG SCANNER NO7&8 (80 PARAMETERS)

RSL A/R8	*VOLTAGE 1/R8	*VOLTAGE
RSL B/R8	*VOLTAGE 2/R8	*VOLTAGE
EYE A-1/R8 } BASEBAND MONITOR	*VOLTAGE 3/R8	SPARE
EYE A-2/R8	*VOLTAGE 4/R8	SPARE
EYE A-3/R8	*VOLTAGE 5/R8	SPARE
EYE B-1/R8 } PARAMETERS MEASURED BY MULTIPLEXING BASEBAND MONITOR	*VOLTAGE 6/R8	SPARE
EYE B-2/R8	*VOLTAGE 7/R8	SPARE
EYE B-3/R8	*VOLTAGE 8/R8	SPARE
MAIN FRAME BIT ERR NORM/T6	*VOLTAGE 1/T6	
CONTROL REFRAME NORM/T6	*VOLTAGE 2/T6	
MAIN FRAME BIT ERR STBY/T6	*VOLTAGE 3/T6	
Rx IN SERVICE/R8	*VOLTAGE 4/T6	
Rx SQUELCH A/R8	*VOLTAGE 5/T6	
Rx SQUELCH B/R8	*VOLTAGE 1/W2	
Rx IN SERVICE/T6	*VOLTAGE 2/W2	
CONTROL REFRAME STBY/T6	*VOLTAGE 3/W2	
FRAME BIT ERROR/W2	*VOLTAGE 4/W2	
REFRAME/W2	*VOLTAGE 5/W2	
REFRAME/W3	*VOLTAGE 6/W2	
FRAME BIT ERROR/W3	*VOLTAGE 1/W3	
MAIN FRAME BIT ERR STBY/T7	*VOLTAGE 2/W3	
CONTROL REFRAME STBY/T7	*VOLTAGE 3/W3	
Rx IN SERVICE/T7	*VOLTAGE 4/W3	
Rx SQUELCH B/R9	*VOLTAGE 5/W3	
Rx SQUELCH A/R9	*VOLTAGE 6/W3	
Rx IN SERVICE/R9	*VOLTAGE 1/T7	
MAIN FRAME BIT ERR NORM/T7	*VOLTAGE 2/T7	
CONTROL REFRAME NORM/T7	*VOLTAGE 3/T7	
EYE B-1/R9 } PARAMETERS MEASURED BY MULTIPLEXING BASEBAND MONITOR	*VOLTAGE 4/T7	
EYE B-2/R9	*VOLTAGE 5/T7	
EYE B-3/R9	*VOLTAGE 1/R9	
EYE A-1/R9 } PARAMETERS MEASURED BY MULTIPLEXING BASEBAND MONITOR	*VOLTAGE 2/R9	
EYE A-2/R9	*VOLTAGE 3/R9	
EYE A-3/R9	*VOLTAGE 4/R9	
RSL B/R9	*VOLTAGE 5/R9	
RSL A/R9	*VOLTAGE 6/R9	

* OPTIONA



BUILDING

- BATTERY CHARGER
- DC/AC INVERTER
- W.G. PRESSURE
- W.G. HUMIDITY
- A.C. DOWER
- BATTERY STATUS
- SITE

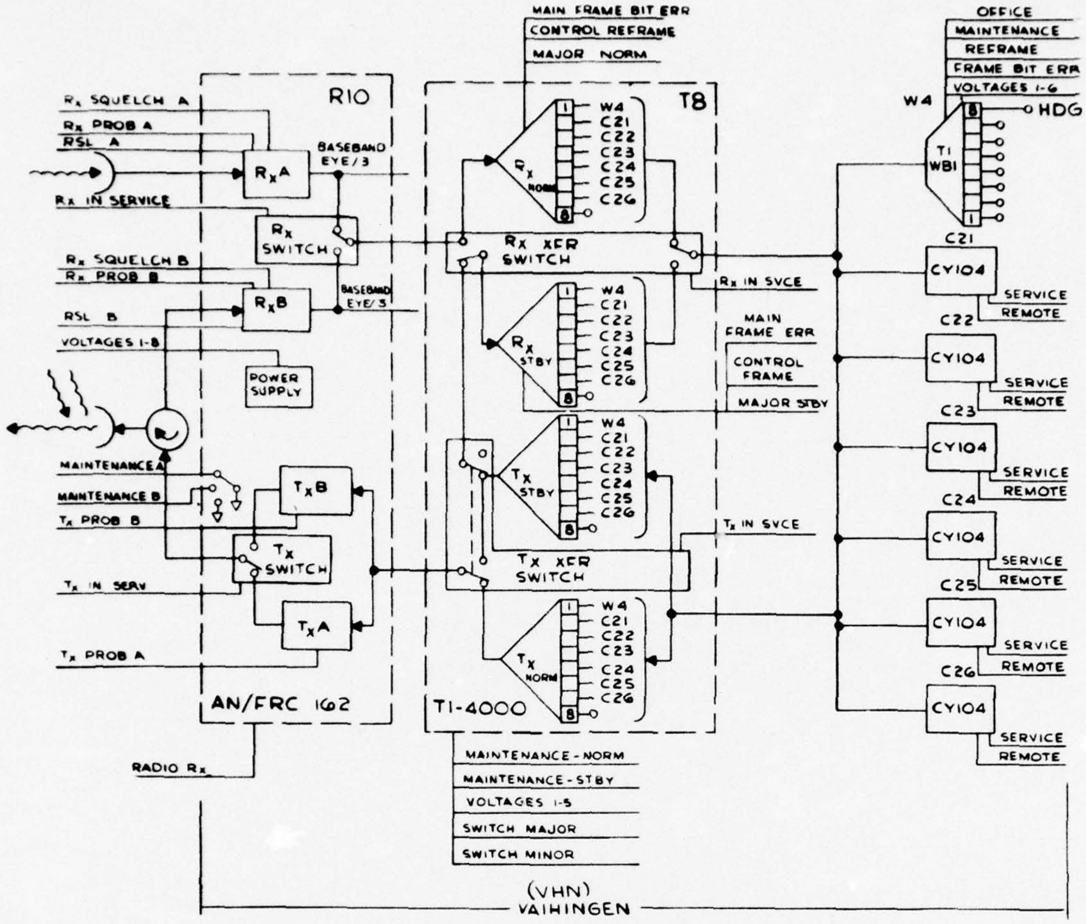
BASEBAND MONITOR
- EYE NOISE
- EYE AMPL
- EYE BURSTS

OG SCANNER NO 7 & 8 (80 PARAMETERS)

	#VOLTAGE 1/R8	#VOLTAGE 7/R9
	#VOLTAGE 2/R8	#VOLTAGE 8/R9
BASEBAND MONITOR	#VOLTAGE 3/R8	SPARE
	#VOLTAGE 4/R8	SPARE
	#VOLTAGE 5/R8	SPARE
PARAMETERS MEASURED BY MULTIPLEXING BASEBAND MONITOR	#VOLTAGE 6/R8	SPARE
	#VOLTAGE 7/R8	SPARE
	#VOLTAGE 8/R8	SPARE
BIT ERR NORM/T6	#VOLTAGE 1/T6	
FRAME NORM/T6	#VOLTAGE 2/T6	
BIT ERR STBY/T6	#VOLTAGE 3/T6	
CE /R8	#VOLTAGE 4/T6	
A /R8	#VOLTAGE 5/T6	
B/R8	#VOLTAGE 1/W2	
CE/T6	#VOLTAGE 2/W2	
FRAME STBY/T6	#VOLTAGE 3/W2	
ERROR /W2	#VOLTAGE 4/W2	
W2	#VOLTAGE 5/W2	
W3	#VOLTAGE 6/W2	
RROR/W3	#VOLTAGE 1/W3	
BIT ERR STBY/T7	#VOLTAGE 2/W3	
AME STBY/T7	#VOLTAGE 3/W3	
CE /T7	#VOLTAGE 4/W3	
B/R9	#VOLTAGE 5/W3	
A/R9	#VOLTAGE 6/W3	
CE /R9	#VOLTAGE 1/T7	
BIT ERR NORM/T7	#VOLTAGE 2/T7	
RAME NORM/T7	#VOLTAGE 3/T7	
PARAMETERS MEASURED BY MULTIPLEXING BASEBAND MONITOR	#VOLTAGE 4/T7	
	#VOLTAGE 5/T7	
	#VOLTAGE 1/R9	
PARAMETERS MEASURED BY MULTIPLEXING BASEBAND MONITOR	#VOLTAGE 2/R9	
	#VOLTAGE 3/R9	
	#VOLTAGE 4/R9	
	#VOLTAGE 5/R9	
	#VOLTAGE 6/R9	# OPTIONAL

FIGURE 3-12. ALARM/PARAMETER MONTIOR POINT LIST STUTTGART

2



ALARM SCANNER NO 2 (40 ALARMS)

Rx SQUELCH A/R10
Rx PROBLEM A/R10
Rx SQUELCH B/R10
Rx PROBLEM B/R10
• RADIO Rx/R10
MAINTENANCE A/R10
MAINTENANCE B/R10
Tx PROBLEM A/R10
Tx PROBLEM B/R10
MAJOR NORM / T8
MAJOR STBY / T8
• SWITCH MAJOR / T8
SWITCH MINOR / T8
MAINTENANCE NORM / T8
MAINTENANCE STBY / T8
Rx IN SERVICE / R10
Tx IN SERVICE / R10
Rx IN SERVICE / T8
Tx IN SERVICE / T8
• OFFICE / W4
MAINTENANCE / W4
REFRAME / W4
• SERVICE / C21
REMOTE / C21
• SERVICE / C22
REMOTE / C22
• SERVICE / C23
REMOTE / C23
• SERVICE / C24
REMOTE / C24
• SERVICE / C25
REMOTE / C25
• SERVICE / C26
REMOTE / C26
BATTERY CHARGER
W.G. PRESSURE } OR'D
W.G. HUMIDITY } OR'D
TOWER LIGHTS
A.C. POWER
BATTERY STATUS
• SITE

• SUDDEN SERVICE FAILURE SENSING SYSTEM

ANALOG SCANNER NO 2 (40 PARAMETERS)

RSL A / R10
RSL B / R10
EYE A-1 / R10 } BASEBAND MONITOR
EYE A-2 / R10 } BASEBAND MONITOR
EYE A-3 / R10 } BASEBAND MONITOR
EYE B-1 / R10 } PARAMETERS MEASURED BY MULTIPLEXING BASEBAND MONITOR
EYE B-2 / R10 } PARAMETERS MEASURED BY MULTIPLEXING BASEBAND MONITOR
EYE B-3 / R10 } PARAMETERS MEASURED BY MULTIPLEXING BASEBAND MONITOR
MAIN FRAME BIT ERR NORM / T8
CONTROL REFRAME NORM / T8
MAIN FRAME BIT ERR STBY / T8
CONTROL REFRAME STBY / T8
Rx IN SERVICE / R10
Rx SQUELCH A / R10
Rx SQUELCH B / R10
Rx IN SERVICE / T8
FRAME BIT ERR / W4
REFRAME / W4
* VOLTAGE 1 / R10
* VOLTAGE 2 / R10
* VOLTAGE 3 / R10
* VOLTAGE 4 / R10
* VOLTAGE 5 / R10
* VOLTAGE 6 / R10
* VOLTAGE 7 / R10
* VOLTAGE 8 / R10
* VOLTAGE 1 / T2
* VOLTAGE 2 / T2
* VOLTAGE 3 / T2
* VOLTAGE 4 / T2
* VOLTAGE 5 / T2
* VOLTAGE 1 / W4
* VOLTAGE 2 / W4
* VOLTAGE 3 / W4
* VOLTAGE 4 / W4
* VOLTAGE 5 / W4
* VOLTAGE 6 / W4
SPARE
SPARE
SPARE
SPARE
SPARE
SPARE

* OPTIONAL

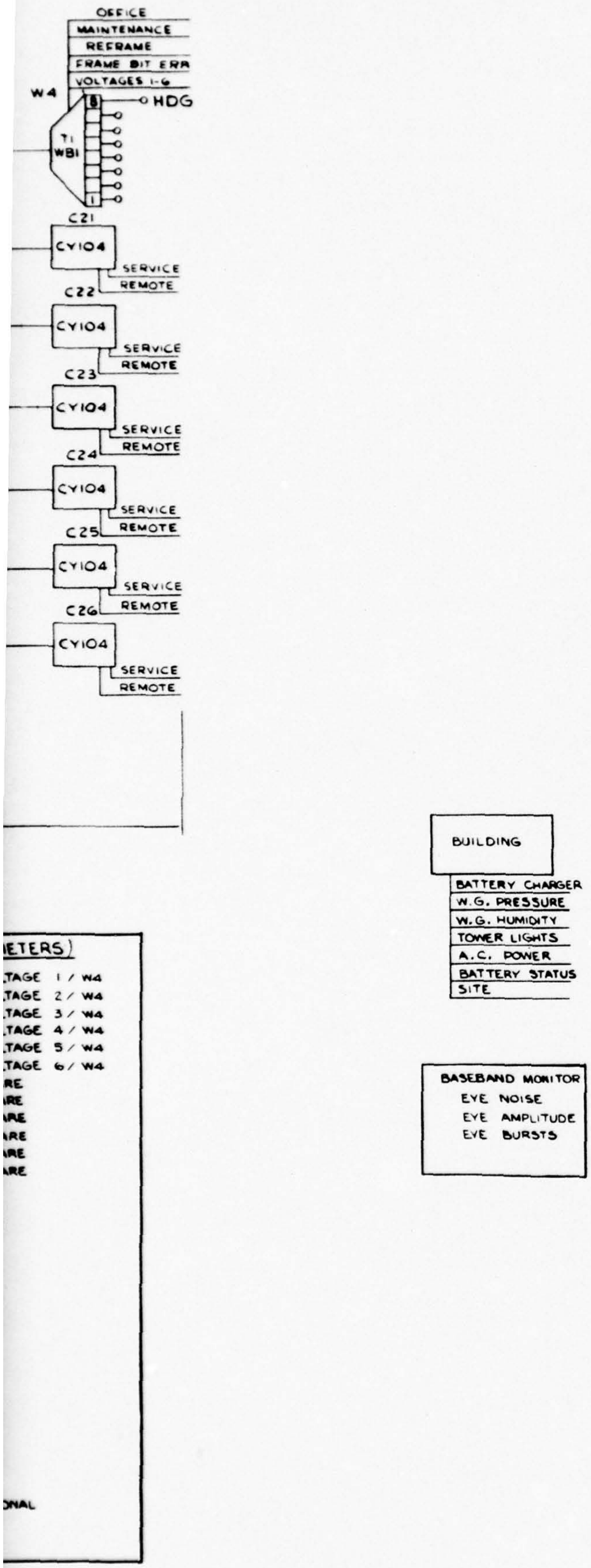


FIGURE 3-13. ALARM/PARAMETER MONITOR POINT LIST VAIHINGEN

3.8 REJECTED MONITOR POINTS

3.8.1 Introduction

The following paragraph details the specific justifications and reasons for deleting previously recommended monitor points. Initially, potential system monitor points were each evaluated on their individual merits. In addition, at that time the overall monitoring system concept was in an evolutionary state. As a result, given that the system concept has solidified, monitor points may be eliminated due to the fact that they are not pertinent or necessary in light of the final monitor system requirements. Also, when all monitor points are considered as a totality some may be eliminated on the basis of redundancy. Lastly, when the multiplicity of monitor points is considered, some may be eliminated on the basis that while they may be of some use, they are not actually required for effective monitor system operation and are not cost effective.

3.8.2 AN/FRC-162 Radio Rejected Monitor Points

Rejected or consolidated radio monitor points are shown in Tables 3-24 and 3-25. The reasons for rejection are also summarized in the tables.

Several parameter measurements at the radio system level have been deleted due to the fact that similar or improved measurements may be made at the radio-multiplexer interface by means of the baseband monitor. Noise bursts are measured directly by the baseband monitor. A wideband noise measurement --- representing all the noise in the partial response signal bandwidth --- is made by the baseband monitor, thereby removing the requirement for a radio slot noise measurement. Obviously, a slot noise measurement may fail to detect noise normally detected by a wideband noise measurement and hence the wideband noise measurement is a better indicator of system performance.

Receiver frequency and transmitter frequency have been classified as secondary parameters. That is, they are parameters which need not be monitored in order to detect a gradual degradation since the degradation may be detected by other measurements.

Change of modulation or demodulation characteristics which cause loss or reduction in Rx Pilot level also affect the amplitude of the signal which is given as a baseband monitor output. A receiver frequency offset, if significant, may be detected by an increased or high level of signal distortion which manifests itself as increased eye pattern scatter --- a parameter measured by

TABLE 3-24. REJECTED MONITOR CANDIDATES AN/FRC-162

ALARMS

MONITOR POINTS	BASIS FOR REJECTION
TX PWR (A&B) TX AFC (A&B) TX PILOT (A&B)	3 BASIC TX ALARMS "ORed" AS TX PROBLEM ALARM SINCE OCCURRENCE OF ANY OF THE THREE INDICATES TX PROBLEM. TX PROBLEM = TX PWR + TX AFC + TX PILOT.
RX PHASELOCK (A&B)	RX PHASELOCK AND SQUELCH ALARMS "ORed" AS AN RX PROBLEM ALARM SINCE OCCURRENCE OF EITHER INDICATES AN RX PROBLEM. RX PROBLEM = RX PHASELOCK + RX SQUELCH.
FM SUBCARRIER (COM BB)	LOSS OF SERVICE CHANNEL EVIDENT FROM LOSS OF MONITORING TELEMETRY FROM SITE.
RX SW CONTROL (COM BB)	LOSS OF SWITCH CONTROL CAN BE DEDUCED FROM SQUELCH ALARM AND RX IN SERVICE INDICATOR. EXAMPLE - IF A SQUELCH ALARM IS ON AND B SQUELCH ALARM IS OFF, SWITCH IS BAD IF A IS IN SERVICE.
RX SUBCXR DEMOD (COM BB)	LOSS OF SERVICE CHANNEL EVIDENT FROM LOSS OF MONITORING TELEMETRY FROM SITE.
TX/RX POWER SUPPLY (A&B) ANC POWER SUPPLY (A&B) PRIMARY POWER (A&B) FUSE, ALARM	ALL POWER SUPPLY DC VOLTAGES, WHICH ARE MORE INFORMATIVE, ARE MONITORED IN PREVENTIVE MAINTENANCE SCAN.
RX OFF NORMAL	REPLACED WITH MANUAL MAINTENANCE STATUS INDICATOR WHICH PROVIDES EQUIVALENT OR MORE INFORMATION THAT MAINTENANCE IS IN PROGRESS.

TABLE 3-25. REJECTED MONITOR CANDIDATES AN/FRC-162

PARAMETERS

MONITOR POINTS	BASIS FOR REJECTION
RX FREQ (A&B)	SECONDARY PARAMETER; BASEBAND MONITORING PROVIDES A MORE ACCURATE MEASURE OF SYSTEM DEGRADATION.
RX SLOT NOISE (A&B)	MORE INFORMATIVE NOISE MEASUREMENTS MADE BY BASEBAND MONITOR (SEE COMMENT IN PARAGRAPH 3.8.2).
TX POWER (A&B)	ISOLATION OF TRANSMITTER DEGRADATION OBTAINED BY COMPARISON OF A&B RECEIVER RSL AND EYE NOISE.
TX FREQ (A&B)	SECONDARY PARAMETER; BASEBAND MONITOR DETECTS FINAL EFFECTS OF DEGRADATION ON SIGNAL (SEE COMMENT IN PARAGRAPH 3.8.2).
RX NOISE BURST (A&B)	THIS PARAMETER IS MEASURED BY MEANS OF THE BASEBAND MONITOR.

the baseband monitor. Similarly, a transmit frequency problem may be detected by means of the baseband monitor. The particular transmitter with a frequency offset can be detected by noting which transmitter was on line when the increased eye pattern scatter was measured.

In the case of a relatively constant path loss, a reduction in transmitter power may be detected by measuring RSL and eye scatter noise. If the path is constant, a reduction in RSL accompanied by a gain in noise indicates reduced transmitter power.

3.8.3 T1-4000 Multiplexer Rejected Monitor Points

Candidate T1-4000 monitor points which were rejected in the final analysis are listed in Table 3-26.

Note that monitor points which reveal only the continuity of in-plant cables have been classed as superfluous and deleted as the cables are in-plant and usually between co-located equipments.

3.8.4 T1WB1 Multiplexer Rejected Monitor Points

Candidate T1WB1 monitor points which were rejected in the final analysis are listed in Table 3-27. The comments addressed toward monitoring the continuity of in-plant cables presented previously also apply to the T1WB1.

3.8.5 CY-104 PCM/TDM Rejected Monitor Points

Candidate CY-104 monitor points which were rejected in the final analysis are listed in Table 3-28. Note that the desirable parameter Framing Bit Miscompares (D2) cannot be measured due to inaccessibility.

TABLE 3-26. REJECTED MONITOR CANDIDATES T1-4000

MONITOR POINTS	BASIS FOR REJECTION
3 LPR AFTER AGC	REQUIRES MODIFICATION TO T1-4000 MULTIPLEXER TO INSTALL EYE PATTERN MONITOR IN MULTIPLEXER. ATEC PHILOSOPHY IS TO ANALYZE INTERFACE SIGNALS WHERE APPROPRIATE AND NOT TO MODIFY HARDWARE BEING MONITORED. COST EFFECTIVENESS IS ALSO CONSIDERED. 3 LPR QUALITY IS MONITORED AT RADIO-MULTIPLEXER INTERFACE BY BASEBAND MONITOR.
3 LEVEL VIOLATION DETECTOR ERROR DENSITY DETECTOR	NOT REQUIRED; EYE PATTERN AND FRAME BIT ERROR MONITORS TOGETHER PROVIDE MORE PRECISE INFORMATION.
T1 BIPOLAR OUTPUT ACTIVITY	TRIVIAL; IN-STATION CABLE BETWEEN EQUIPMENT.
T1 INPUT SIGNALS	TRIVIAL; IN-STATION CABLE BETWEEN EQUIPMENT.
ANALOG TX SIGNAL ACTIVITY	NOT NECESSARY; LOSS OF SIGNAL WILL INITIATE TRANSFER TO STANDBY.
LOOP ALARM	MAINTENANCE CONDITION; SUBSET OF "OUT OF SERVICE" INDICATOR.
FUSE ALARM	NOT REQUIRED - BLOWN FUSE WILL ACTIVATE OTHER ALARMS.
MAIN REFRAME	CONTROL REFRAME MORE SENSITIVE TO DEGRADATION
SEND ALARM-SWITCH REMOTE ALARM-SWITCH	REDUNDANT; AS IN EVENT OF SINGLE FAILURE, FINAL STATE OF SWITCHES WILL DELINEATE EQUIPMENT REQUIRING ATTENTION.
RX AND TX TRANSFER STATUS	DO NOT PROVIDE MEASURE OF PERFORMANCE ASSESSMENT OR MARGIN.

TABLE 3-27. REJECTED MONITOR CANDIDATES

T1WB1

MONITOR POINT	BASIS FOR REJECTION
T1 RCVD BIT STREAM ACTIVITY	TRIVIAL; IN-STATION CABLE BETWEEN EQUIPMENT
RCV OUTPUT DATA ACTIVITY	FAILURE UNLIKELY TO OCCUR WHICH WILL NOT BE EVIDENT BY OTHER MEANS SUCH AS LOSS OF CY-104 TRAFFIC
ERROR CHECK (REDUNDANCY)	PA/FI VALUE DOES NOT WARRANT COMPLEX CIRCUITRY NEEDED; FRAME BIT ERROR MONITOR WILL SUFFICE
CHANNEL INPUT ACTIVITY	FAILURE UNLIKELY TO OCCUR WHICH WILL NOT BE EVIDENT BY OTHER MEANS. SOME CHANNELS NORMALLY INACTIVE
TX T1 OUTPUT	TRIVIAL. IN-STATION CABLE BETWEEN EQUIPMENTS
FUSE ALARM	NOT REQUIRED; WILL GENERATE OFFICE ALARM WHICH IS MONITORED
LOOP ALARM	MAINTENANCE CONDITION; SUBSET OF OUT OF SERVICE INDICATOR

TABLE 3-28. REJECTED MONITOR CANDIDATES
CY-104

MONITOR POINT	BASIS FOR REJECTION
LOOP	MAINTENANCE CONDITION: SUBSET OF "OUT OF SERVICE INDICATOR" A
RESTART (HN-74)	NOT REQUIRED; CONTINUING SERVICE ALARM INDICATES CONDITION
FRAMING BIT MISCOMPARES (D2)	DESIRABLE PARAMETER. CANNOT MONITOR IN DEMONSTRATION DUE TO INACCESSIBILITY

3.9 FKV SYSTEM ALARM SIMULATION AND MULTIPORT DATA COLLECTION SIMULATION

3.9.1 FKV System Alarm Simulation

The candidate alarms and parameters which could be monitored in the FKV System are enumerated and discussed in Appendices A1-A5. Alarm cascading caused by a failure(s) at any particular monitor point(s) was of special interest as a test bed for fault isolation, and as a measure of the effectiveness of any proposed candiate monitoring schemes.

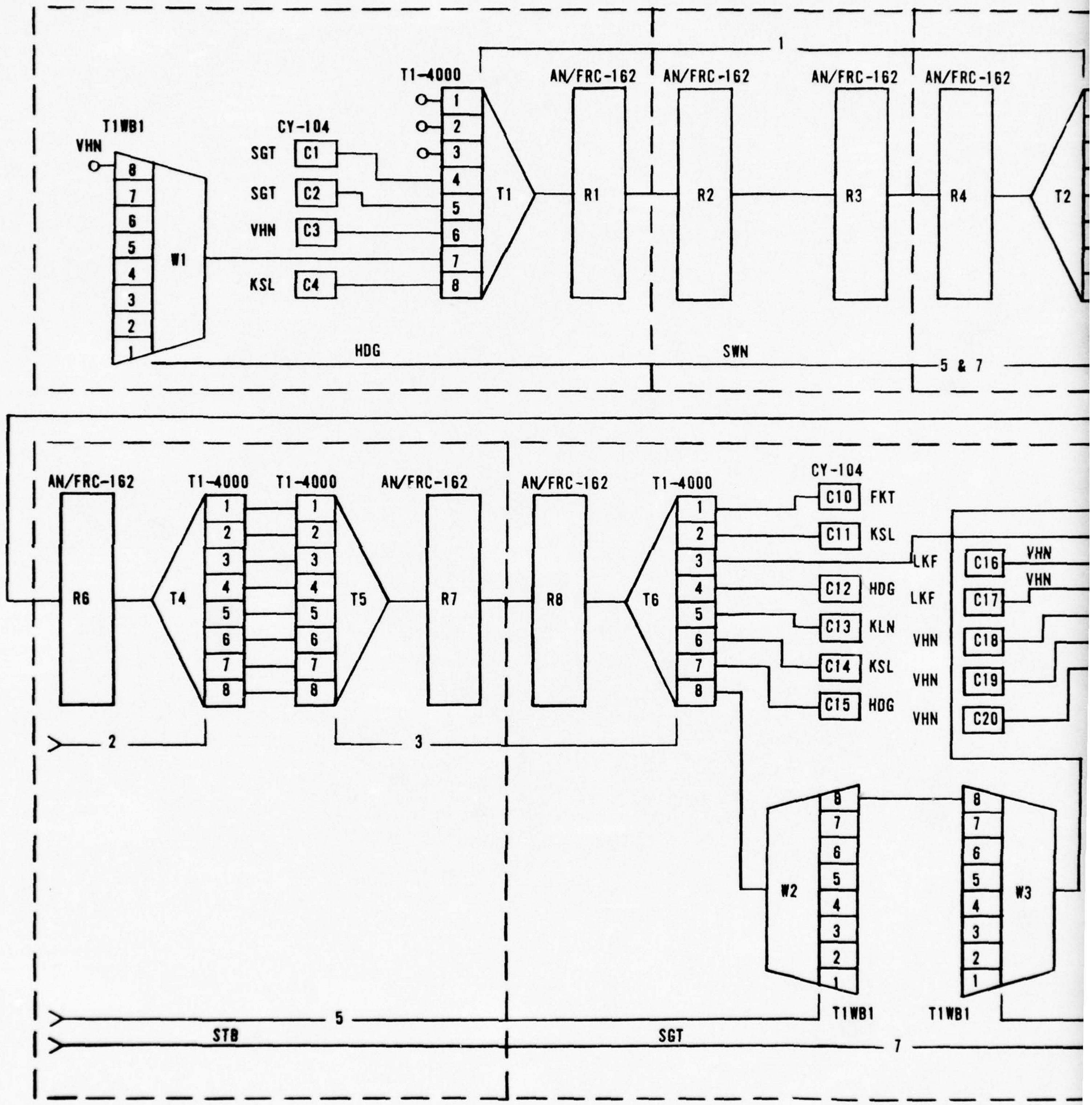
Typical alarm cascading could be demonstrated by careful analysis of the candidate monitor points and their interrelationships. However, a simulation of the FKV System would provide data which might otherwise be overlooked, e.g., which monitor points provided redundant or similar information on specific failures. Simulation insures that all monitor points affected by a specific failure are noted.

Time did not allow a complete simulation of the FKV; therefore, the link from HDG to VHN (Figure 3-14) was chosen as an adequate example which contained a full complement of the FKV equipments.

The program (Simulator) was designed in three basic segments (see Figure 3-15). The first is an initialization routine which sets up the in-core data base from disk files. This data base describes the interrelationship of those alarms and parameters to be included in the simulation. The second and third segments are alternated until the end simulation time, specified as input to the program, is reached. The second segment provides for alarm and parameter generation based on equations determined from hardware descriptions of the equipments (as specified in the data base).

During this portion of the program every alarm and parameter is recalculated to reflect any changes that have occurred since the last time this segment was executed. The final segment is the scan simulation which performs the actual update of any alarms and parameters with new values as calculated in segment 2. At this time all updated alarms are also output; and simulation time is incremented.

An actual computer output is shown in Table 3-29, located at the end of the discussion. Note that the printout shows some



1
T1-4000
AN/FRC-162
AN/FRC-162
AN/FRC-162
AN/FRC-162
T1WB1
CY-104
VHN
SGT
C1
SGT
C2
VHN
C3
KSL
C4
W1
T1
R1
R2
R3
R4
T2
HDG
SWN
5 & 7
AN/FRC-162
T1-4000
T1-4000
AN/FRC-162
AN/FRC-162
T1-4000
CY-104
C10
FKT
C11
KSL
LKF
C16
VHN
VHN
C12
HDG
LKF
C17
C13
KLN
VHN
C18
C14
KSL
VHN
C19
C15
HDG
VHN
C20
R6
T4
T5
R7
R8
T6
2
3
W2
W3
5
T1WB1
T1WB1
STB
SGT
7

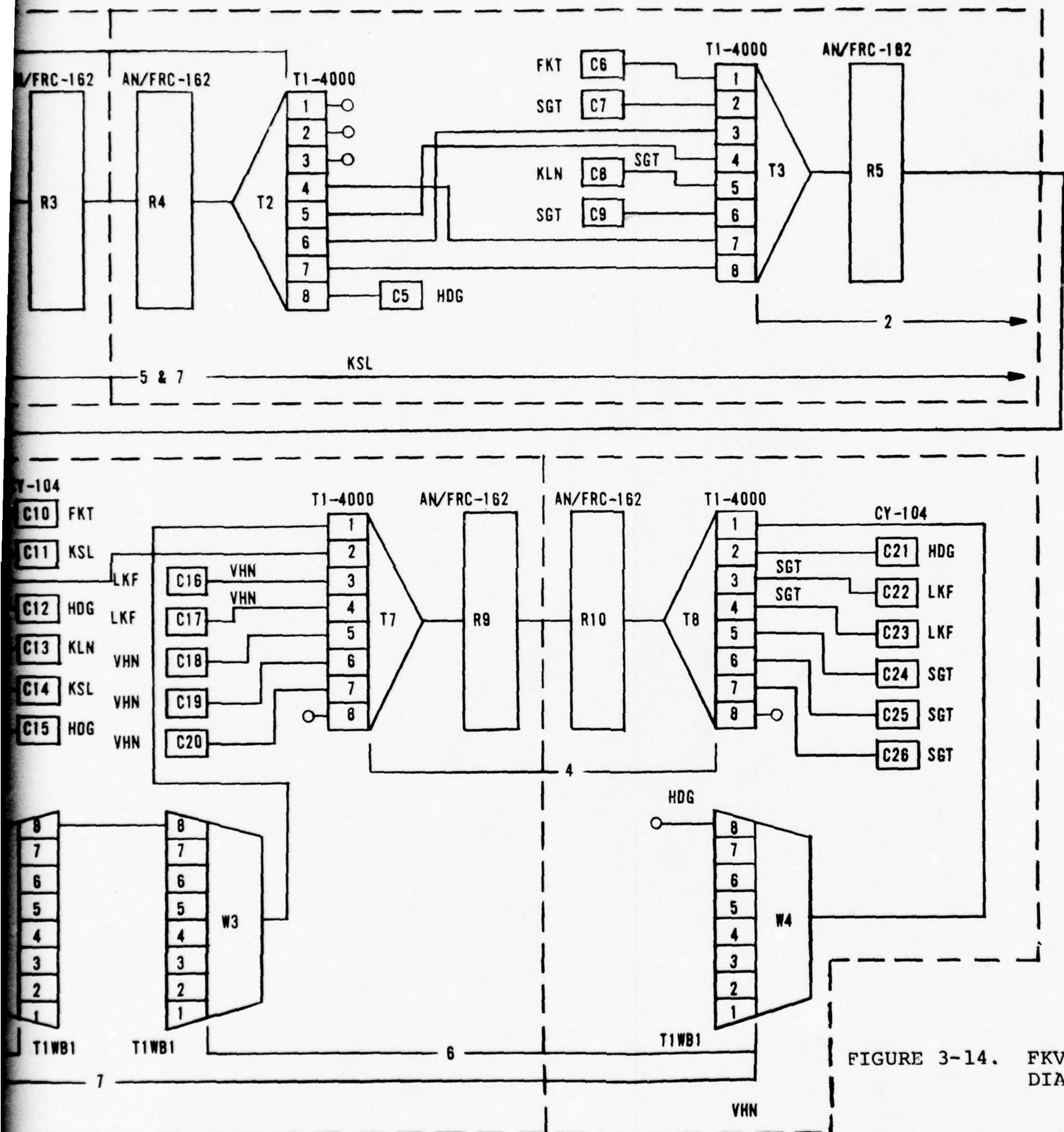


FIGURE 3-14. FKV SYSTEM DIAGRAM

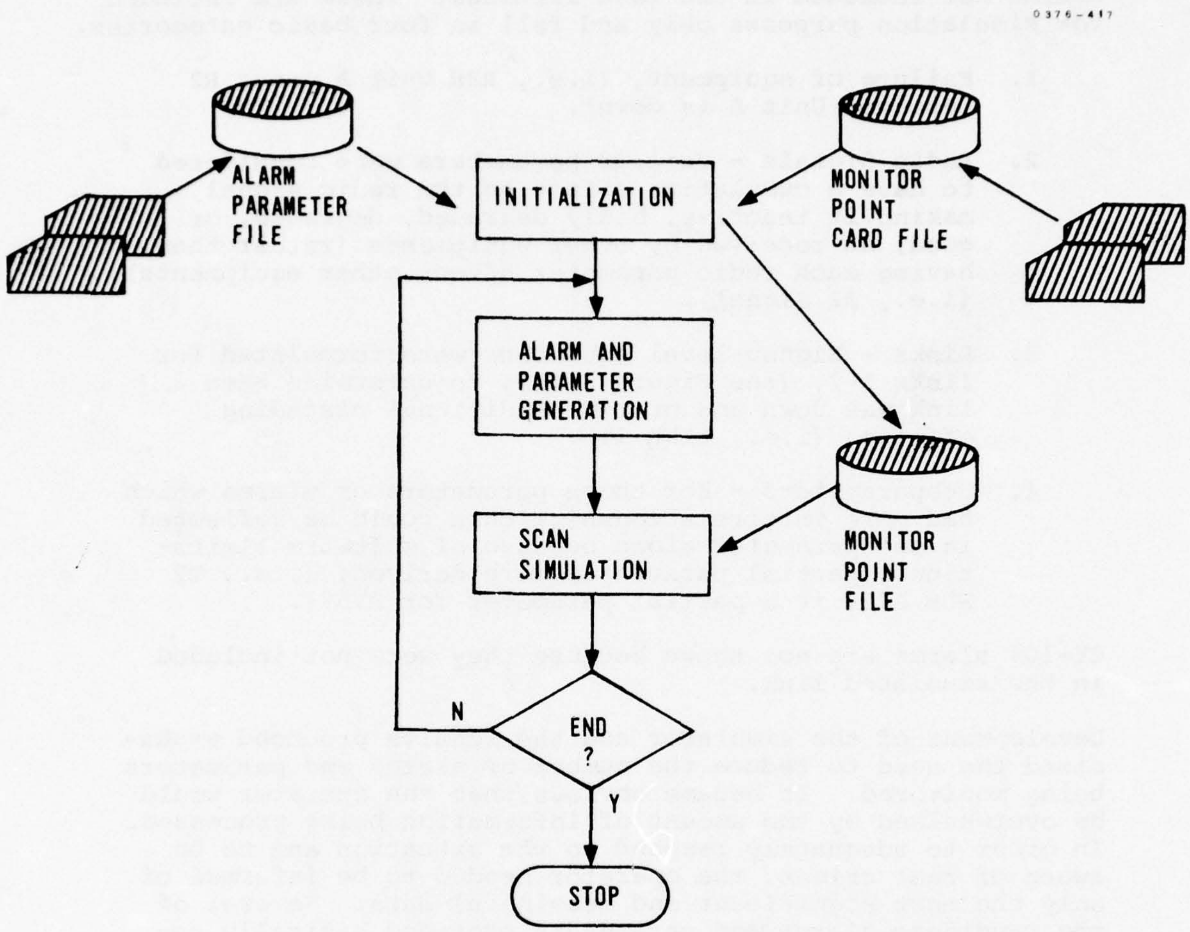


FIGURE 3-15. DIGITAL ATEC SIMULATOR

alarms not included in the text listings. These are included for simulation purposes only and fall in four basic categories.

1. Failure of equipment, (i.e., R2R Unit A means R2 Receiver Unit A is down).

2. Radio Signals - Various parameters were considered to have a cumulative effect on the radio signal, making it inactive, badly degraded, degraded, or good, as received by other equipments (rather than having each radio parameter affect other equipments), (i.e., R2 Signal).

3. Links - Higher level equations were formulated for links 1-7, (see Figure 3-14), to determine when a link was down and provide additional cascading effects, (i.e., LINK 1T).

4. Subparameters - For those parameters or alarms which had more interrelationships than could be reflected in one parameter alone because of software limitations, partial parameters were derived, (i.e., T2 SUB A757 is a partial parameter for A757).

CY-104 alarms are not shown because they were not included in the simulated link.

Development of the simulator and the results produced emphasized the need to reduce the number of alarms and parameters being monitored. It became obvious that the operator would be overwhelmed by the amount of information being processed. In order to adequately respond to the situation and to be aware of real crises, the operator needed to be informed of only the most significant and meaningful data. Several of the candidate alarms and parameters provided basically redundant information and, therefore, could be combined or eliminated. Others, supplying useful information for fault isolation, could continue to be monitored, but need not be directed to the attention of the operator immediately. This left two alternatives. First - the processor could collect all the candidate monitor points, and maintain a CRT display correlating the information in a manner easily and conviently interpreted by the operator to pinpoint the failure. Second - only those alarms indicative of major failure would be shown on the Alarm Display. The first method would provide more information, but at the cost of overloading the processor and causing undesirable delay before the operator was aware

of the problem. Therefore, the second method, Sudden Service Failure Sensing System (SSFSS), was chosen. The processor will also collect some additional, but drastically reduced number of alarms, for display.

SSFSS is limited to the following major alarms:

ON-LINE EQUIPMENT: (alarms requiring immediate attention, usually as a result of catastrophic equipment failure).

T1-4000	Protective Switch Major Alarm
Radio	A and B Receiver Pilots (AND'ed function, one light)
T1WB1	Office Alarm
CY-104	Service Alarm
Site	One Combined Alarm

A representation of the SSFSS (the Alarm Display with a Nodal Network Diagram) is shown for each site, Figures 3-17 through 3-22. All tables, charts and figures are located following the listings of alarm cascading examples.

For a comparison of the two alternatives see Table 3-30. The following information is given for each specific failure simulated.

1. Failure condition and sites (column 1)

2. Original number of alarms (column 2) which would occur at a large number of monitor points (all candidate alarms). Number includes only those alarms which are constant. Those alarms which occur briefly and correct themselves due to switching of equipment are counted as flashes and are shown in parentheses (i.e., (+9 Flash) Means 9 alarms are transient). The total number of alarms are shown as a summation for each failure condition.

3. SSFSS number of alarms (column 3)
   The number of alarms displayed using the SSFSS. The total number of alarms are shown as a summation for each failure condition.

As is easily seen, the SSFSS greatly simplifies the pinpointing of failures by the operator, because fewer alarms must be considered.

In addition, a pictorial representation (Figures 3-23 through 3-27) demonstrates the simplicity of the SSFSS by depicting the greatly reduced number of major alarms in the SSFSS, which occur as a result of a specified failure (noted by ●). Although the CY-104 equipment was not included in the simulation, alarms affecting this equipment are shown in these figures. These alarms were determined by cause and effect analysis of the links and FKV equipment for the specified failure condition.

3.9.1.1 Computer Printout

Table 3-29, Alarm Listing, is a sample of an actual computer printout which resulted from a simulation of R2 Radio Receive Pilot Failure and demonstrates the cascading effect on the link (Figure 3-14). The printout fields present the following information:

TIME: For those alarms which would occur simultaneously with the failure, an arbitrary time value expressed in milliseconds is used to pictorialize the propagation delay of the cascading alarm effect. Time entries expressed in seconds are used to demonstrate the delays caused by equipment switching sequences before an alarm is generated.

ALARMS: This field contains three separate items of information as follows:

1. A four digit alpha numeric designator which represents identification of the simulated alarm number (i.e., Axxx, where x equals any numeric).
2. The affected equipment. Equipment references are as shown in Figure 3-14, and equipment service condition, (i.e., normal or standby).
3. Signal being measured, i.e., CHANNEL 8 INPUT, BIPOLAR OUT, RCV OUT DATA, etc..

PARAMETERS: Where applicable entries under this heading describe the simulation performance measurement identification number, equipment identification, operating condition or performance parameter.

For each line entry the far right column describes alarm condition or parameter condition, i.e., ALARM; NO ALARM; GOOD; BADLY DEGRADED; INACTIVE.

A typical example of alarm cascading using this simulator would show the following:

Failure Condition: R2A and R2B RCVR Pilots

RESULTANT ALARMS BY SITE:

HDG	●	W1	Office Alarm
		T1	Remote Alarm
		T1	Normal Major Alarm
	●	T1	Protective Switch Major Alarm
		T1	Tx XFER Status
		T1	Standby Reframe
		T1	Protective Switch Minor Alarm
		T1	Standby Demod Eye Pattern
		T1	Standby 3 Level Violation Detector
		T1	Standby Frame Bit Error
	●	C1	Service Alarm
	●	C2	Service Alarm
	●	C3	Service Alarm
	●	C4	Service Alarm

SWN	●	R2A	RCVR Pilot
	●	R2B	RCVR Pilot
		R2A	Rx Switch
		R2B	Rx Switch
KSL		T2	Normal Reframe
		T2	Normal Demod Eye Pattern
		T2	Normal 3 Level Violation Detector
		T2	Normal Frame Bit Error
		T2	Standby Major Alarm
		T2	Normal Major Alarm
		T2	Send Alarm
	●	T2	Protective Switch Major Alarm
		T2	Normal Bipolar Out
		T3	Normal Channel 8 Input
		T3	Standby Channel 8 Input
	●	C5	Service Alarm
		C5	Remote Alarm

FLASHING ALARMS (caused by equipment switching)

T2	Rx Transfer Status
T2	Standby Reframe
T2	Protective Switch Minor Alarm
T2	Standby Demod Eye Pattern
T2	Standby 3 Level Violation Detector
T2	Standby Bipolar Out

		T2	Standby Frame Bit Error
		T3	Normal Channel 8 Input
		T3	Standby Channel 8 Input
SGT		W2	Bit Frame Error
		W2	Error Check
		W2	Reframe
	•	W2	Office Alarm
	•	C15	Service Alarm
		C15	Remote Alarm
	•	C12	Service Alarm
		C12	Remote Alarm
		T6	Normal Bipolar Out
		W2	T1 Receive Bit Stream
		W2	Channel 8 Rx Out
		W3	Channel 8 Input
VHN	•	C21	Service Alarm
		C21	Remote Alarm
		W4R	Channel RCV Out Data
STB		T4R	Normal Bipolar Out
		T5T	Normal Channel 8 Input
		T5T	Standby Channel 8 Input

W4T Fuse Alarm

Failure Condition

RESULTANT ALARMS BY SITE:

HDG		W1R	Channel 8 RCV Out Data
SGT		W3R	T1 RCV Bit Stream
		W3	Bit Frame Error
		W3R	Channel 8 RCV Out Data
		W3	Error Check
		W3	Reframe
		W2T	Channel 8 Input
	●	W3	Office Alarm
		T7	Normal Bipolar Out
VHN		W4T	Fuse Alarm
		W4	DC Voltage
		W4T	TxT1 Output
		W4R	Channel RCV Out Data
	●	W4	Office Alarm
		T8T	Normal Channel 1 Input
		T8T	Standby Channel 1 Input

W1T Fuse Alarm

Failure Condition

RESULTANT ALARMS BY SITE:

HDG	W1T	Fuse Alarm
	W1	DC Voltage
	W1R	Channel 8 RCV Out Data

	W1T	TxT1 Output
	• W1	Office Alarm
	T1T	Normal Channel 7 Input
	T1T	Standby Channel 7 Input
SGT	W2R	T1 RCV Bit Stream
	W2	Bit Frame Error
	W2R	Channel 8 RCV Out Data
	W2	Error Check
	W3T	Channel 8 Input
	W2	Reframe
	• W2	Office Alarm
VHN	W4R	Channel RCV Out Data

W2T Fuse Alarm

Failure Condition

RESULTANT ALARMS BY SITE:

HDG	W1R	T1 RCV Bit Stream
	W1	Bit Frame Error
	W1R	Channel 8 RCV Out Data
	W1	Error Check
	W1	Reframe
	• W1	Office Alarm
	T1	Protective Switch Minor Alarm
	T1	Normal Bipolar Out

KSL	T3	Normal Bipolar Out
	T2	Normal Channel 7 Input
	T2	Standby Channel 7 Input
STB	T5	Normal Bipolar Out
	T4	Normal Channel 8 Input
	T4	Standby Channel 8 Input
SGT	W2T	Fuse Alarm
	W2	DC Voltage
	W2T	TxTl Output
	W2R	Channel 8 RCV Out Data
	W2R	Tl RCV Bit Stream
	• W2	Office Alarm
	W3T	Channel 8 Input
	T6T	Normal Channel 8 Input
	T6T	Standby Channel 8 Input
VHN	W4R	Channel RCV Out Data

RlA Tx Power Failure

Failure Condition

RESULTANT ALARMS BY SITE:

HDG	RlA	Tx Power
	RlA	Tx Power Alarm
	RlT	A Unit in Service
	Wl	Office Alarm (flash)
KSL	T2	Normal Reframe (flash)

	T2	Normal Demod Eye Pattern (flash)
	T2	Normal 3 Level Violation Detector (flash)
	T2	Normal Frame Bit Error (flash)
SGT	W2	Bit Frame Error (flash)
	W2	Error Check (flash)
	W2	Office Alarm (flash)
	W2	Reframe (flash)

R7 A and B RCVR Pilot

Failure Condition

RESULTANT ALARMS BY SITE:

HDG	W1	Bit Frame Error
	W1	Error Check
	W1	Reframe
	• W1	Office Alarm
	• C1	Service
	• C2	Service
	• C3	Service
KSL	• C6	Service
	• C7	Service
	• C8	Service
	• C9	Service
STB	R7A	Rx Switch
	R7B	Rx Switch
	• R7A	RCVR Pilot
	• R7B	RCVR Pilot

		T5	Normal Reframe
		T5	Normal 3 Level Violation Detector
		T5	Normal Frame Bit Error
		T5	Standby Major Alarm
		T5	Normal Major Alarm
		T5	Send Alarm
	●	T5	Protective Switch Major Alarm
		T5	Normal Demod Eye Pattern
FLASHING:			
		T5	Rx XFER Status
		T5	Standby Reframe
		T5	Protective Switch Minor Alarm
		T5	Standby Demod Eye Pattern
		T5	Standby Bipolar Out
		T5	Standby 3 Level Violation Detector
		T5	Standby Frame Bit Error
		T4T	Normal Channel 8 Input
		T4T	Standby Channel 8 Input
SGT	●	W2	Office Alarm
		T6	Remote Alarm
		T6	Normal Major Alarm
	●	T6	Protective Switch Major Alarm
		T6	Tx XFER Status
		T6	Standby Reframe

	T6	Protective Switch Minor Alarm
	T6	Standby Demod Eye Pattern
	T6	Standby 3 Level Violation Detector
	T6	Standby Frame Bit Error
	● C10	Service
	C10	Service
	● C11	Service
	C11	Remote
	● C12	Service
	C12	Remote
	● C13	Service
	C13	Remote
	● C14	Service
	C14	Remote
	● C15	Service
	C15	Remote
VHN	● C21	Service
	C21	Remote

LINK DATA ROUTINE FROM HEIDELBERG TO VAIHINGEN

HDG	C1 → SGT C15
	C2 → SGT C12
	C3 → VHN C21
	C4 → KSL C5
KSL	C6 → SGT C10
	C7 → SGT C11
	C8 → SGT C13

SGT

C9 → SGT C14

C16 → VHN C22 → LKF

C17 → VHN C22 → LKF

C18 → VHN C24

C19 → VHN C25

C20 → VHN C26

3.9.1.2 Conditional Equations

This section contains a sampling of the conditional equations used in the FKV alarm simulation. The equations are keyed to the printout, Table 3-29 by time of entry, (i.e., the equation for R2A Rx switch is found at time 0.1000E-2) and by the initial alarm simulated monitor point entered at that time (for the cited example; A853). Demonstrating the example quoted above:

TIME = 0.1000E-02, A853:

R2A Rx Switch = R2A Rx Pilot + R2A Tx/Rx Power + R2A Auxiliary Power

R2 Rx Pilot = R2A Rx Pilot. No Change to Unit B + R2B Rx Pilot. Change to Unit B

R2B Rx Switch = R2B Rx Pilot + R2B Tx/Rx Power + R2B Auxiliary Power

MIL-STD-806B logic notation is used throughout where:

+ (a plus sign) = OR function

. (a line centered dot) = AND function

Brackets and parenthesis are used as in any algebraic equation.

TIME = 0.6000E-02, A005

LINK 7T = Link 6T + Link 5T
W2 REFRAME = W2 Bit Frame Error
T2T T1-4000 = T2T Normal Mux · No Tx transfer + T2T Standby Mux · Tx transfer

(Note: Table 3-29 contains a printing error for this alarm. Delete T7R after T2T, Alarm Number A740.)

T2 NORMAL FRAME BIT ERROR = T2 Normal 3 level Violation

T2R FRAME BIT ERROR = T2R 3 Level Violation Detector

TIME = 0.2700E-01, A742

T2R STANDBY MUX = T2 Standby dc voltage + T2 Standby Loop Alarm + T2R Standby reframe + badly degraded T2R + inactive T2R Standby Demod eye pattern.

T2 STANDBY BIPOLAR OUT = [(T2T Standby input + T2T Standby analog Tx signal) · (NO Rx Transfer · NO Tx Transfer + T2 Standby dc voltage + T2 Send Alarm + (Tx Transfer · NO Rx Transfer)] + Rx Transfer · (T1 Input + T1T Analog Tx signal + R4 signal inactive)

(Note: This equation is divided into two sections as indicated by brackets.)

T2 20MS TIMER = T2 Normal reframe · NO Protective Switch Minor Alarm.

T2R REFRAME = T2 Normal reframe · NO Rx Transfer + T2 Standby reframe · Rx Transfer

T2 STANDBY 3 LEVEL VIOLATION DETECTOR = T2 Standby Demod eye pattern.

TIME = 0.3200E-01, A265

T5T NORMAL CHANNEL 8 INPUT = T4R Normal bipolar out

T5T STANDBY CHANNEL 8 INPUT = T4R Normal bipolar out

T5T CHANNEL 8 INPUT = T4R Normal bipolar out

TIME = 4.427, A695

T1 REMOTE ALARM = T2 Send alarm · Link 1R up

T2 4.4 SEC TIMER = Rx Transfer status (Δt = 4.4 sec.)

T2R NORMAL BIPOLAR OUT = T1T channel 1 input + T2 Normal dc voltage + T2 Send Alarm + R9 Signal inactive + T1 Tx analog signal.

T2 10MS TIMER FOR RX LATCH = Rx Transfer status ($\Delta t = 10$ milliseconds)

T2 PROTECTIVE SWITCH MAJOR ALARM = T2 Remote Alarm + T2 Send Alarm + Tx latch + (Tx Transfer · NO 10MS) + T2 Standby dc voltage

T2 SUB A757 = (T2T channel 1 standby input + T2T standby analog signal) · NO Rx Transfer · NO Tx Transfer + T2 standby dc voltage + T2 Send Alarm + (Tx Transfer · NO Rx Transfer)

T2R CHANNEL 7 BIPOLAR OUT = (T2R Channel 7 Bipolar Out · NO Tx Transfer) + (T2R Channel 7 Bipolar out · Rx Transfer)

T2 STANDBY DEMOD EYE PATTERN = (Maximum if NO T2T Standby Tx analog signal) · (NO Rx Transfer · NO Tx Transfer) + (Tx Transfer · NO Rx Transfer) + (Rx Transfer · R4 Signal) + Maximum if NO T1T Tx analog signal.

In a similar manner, the remaining equations can be derived by use of the FKV Equipment Use Matrix, Figure 3-16.

R2 RADIO PILOT

```
TIME= 0.1000E-02

          ALARMS
          A853 R2A RX SWITCH                                      ALARM
          A873 R2 RX PILOT                                        ALARM
          A887 R2B RX SWITCH                                      ALARM

          PARAMETERS


TIME= 0.2000E-02

          ALARMS
          A836 R2R UNIT A                                         ALARM
          A838 R2R UNIT B                                         ALARM
          A839 R2 2 MS TIMER                                      ALARM
          A864 R2 RX SWITCH                                       ALARM
          A888 R2 2 MS TIMER                                      ALARM

          PARAMETERS
          P158 R2 SIGNAL                                          BADLY DEGRADED


TIME= 0.3000E-02

          ALARMS
          A935 SWN R2R                                            ALARM

          PARAMETERS
          P171 R4SIGNAL                                           BADLY DEGRADED


TIME= 0.4000E-02

          ALARMS
          A077 LINK 1T                                            ALARM
          A765 T2 NORMAL REFRAME                                  ALARM
          A787 R1  TELEMETRY LINK 1T                              ALARM

          PARAMETERS
          P131 T2 NORMAL DEMOD EYE PATTERN                        BADLY DEGRADED
          P138 T2R DEMOD EYE PATTERN                              BADLY DEGRADED


TIME= 0.5000E-02

          ALARMS
          A075 LINK 5T                                            ALARM
          A354 W2 BIT FRAME ERROR                                 ALARM
          A564 W2 ERROR CHECK                                     ALARM
          A741 T2R NORMAL MUX                                     ALARM
          A779 T2R REFRAME                                        ALARM

          PARAMETERS
          P133 T2 NORMAL 3 LEVEL VIOLATION DETECTOR               BADLY DEGRADED
          P139 T2R 3 LEVEL VIOLATION DETECTOR                     BADLY DEGRADED
```

TABLE 3-29.   ALARM LISTING

```
TIME= 0.6000E-02

          ALARMS
          A005 LINK 7T                                                   ALARM
          A470 W2 REFRAME                                                ALARM
          A740 T2T T7R T1-4000                                           ALARM

          PARAMETERS
          P134 T2 NORMAL FRAME BIT ERROR                                 BADLY DEGRADED
          P140 T2R FRAME BIT ERROR                                       BADLY DEGRADED


TIME= 0.7000E-02

          ALARMS
          A304 SGT W2R WB1                                               ALARM

          PARAMETERS


TIME= 0.1100E-01

          ALARMS
          A563 W2 5 MS TIMER                                             ALARM

          PARAMETERS


TIME= 0.1200E-01

          ALARMS
          A147 W1 OFFICE ALARM                                           ALARM
          A513 W2 OFFICE ALARM                                           ALARM

          PARAMETERS


TIME= 0.2400E-01

          ALARMS
          A759 T2 20 MS TIMER                                            ALARM

          PARAMETERS


TIME= 0.2500E-01

          ALARMS
          A743 T2 RX XFER STATUS                                         ALARM

          PARAMETERS
```

TABLE 3-29. ALARM LISTING (CONTINUED)

```
TIME= 0.2600E-01

          ALARMS
          A740 T2T T7R T1-4000                                        NO ALARM
          A749 T2 STANDBY REFRAME                                     ALARM
          A771 T2 PROTECTIVE SWITCH MINOR ALARM                       ALARM
          A772 T2 SUB A757                                            ALARM
          A779 T2R REFRAME                                            NO ALARM

          PARAMETERS
          P135 T2ANDBY DEMOD EYE PATTERN                              BADLY DEGRADED


TIME= 0.2700E-01

          ALARMS
          A742 T2R STANDBY MUX                                        ALARM
          A757 T2 STANDBY BIPOLAR OUT                                 ALARM
          A759 T2 20 MS TIMER                                         NO ALARM
          A779 T2R REFRAME                                            ALARM

          PARAMETERS
          P136 T2 STANDBY 3 LEVEL VIOLATION DETECTOR                  BADLY DEGRADED


TIME= 0.2800E-01

          ALARMS
          A740 T2T T7R T1-4000                                        ALARM
          A775 T2R CHANNEL 7 BIPOLAR OUT                              ALARM

          PARAMETERS
          P137 T2 STANDBY FRAME BIT ERROR                             BADLY DEGRADED


TIME= 0.2900E-01

          ALARMS
          A475 T3T NORMAL CHANNEL 8 INPUT                             ALARM
          A476 T3T STANDBY CHANNEL 8 INPUT                            ALARM
          A517 T3T CHANNEL 8 INPUT                                    ALARM

          PARAMETERS


TIME= 0.3000E-01

          ALARMS
          A543 T4R NORMAL BIPOLAR OUT                                 ALARM

          PARAMETERS


TIME= 0.3100E-01

          ALARMS
```

TABLE 3-29. ALARM LISTING (CONTINUED)

```
          A565 T4R CHANNEL 8 BIPOLAR OUT                                      ALARM

          PARAMETERS


TIME= 0.3200E-01

          ALARMS
          A265 T5T NORMAL CHANNEL 8 INPUT                                     ALARM
          A266 T5T STANDBY CHANNEL 8 INPUT                                    ALARM
          A307 T5T CHANNEL 8 INPUT                                            ALARM

          PARAMETERS


TIME= 0.3300E-01

          ALARMS
          A333 T6R NORMAL BIPOLAR OUT                                         ALARM

          PARAMETERS


TIME= 0.3400E-01

          ALARMS
          A353 W2R T1 RCV BIT STREAM                                          ALARM
          A355 T6R CHANNEL 8 BIPOLAR OUT                                      ALARM

          PARAMETERS


TIME= 0.3500E-01

          ALARMS
          A411 W2R CHANNEL 8 RCV OUT DATA                                     ALARM
          A764 T2 10 MS TIMER FOR RX LATCH                                    ALARM

          PARAMETERS


TIME= 0.3600E-01

          ALARMS
          A061 W3T CHANNEL 8 INPUT                                            ALARM

          PARAMETERS


TIME= 0.3700E-01

          ALARMS
          A137 W4R CHANNEL RCV OUT DATA                                       ALARM

          PARAMETERS
```

TABLE 3-29. ALARM LISTING (CONTINUED)

```
TIME= 0.2540

          ALARMS
          A750 T2 250 MS TIMER                                          ALARM

          PARAMETERS

TIME= 0.2550

          ALARMS
          A746 T2 STANDBY MAJOR ALARM                                   ALARM
          A762 T2 NORMAL MAJOR ALARM                                    ALARM

          PARAMETERS

TIME=  4.425

          ALARMS
          A752 T2 4.4 SEC TIMER                                         ALARM

          PARAMETERS

TIME=  4.426

          ALARMS
          A743 T2 RX XFER STATUS                                        NO ALARM
          A744 T2 SEND ALARM                                            ALARM

          PARAMETERS

TIME=  4.427

          ALARMS
          A695 T1 REMOTE ALARM                                          ALARM
          A752 T2 4.4 SEC TIMER                                         NO ALARM
          A753 T2R NORMAL BIPOLAR OUT                                   ALARM
          A764 T2 10 MS TIMER FOR RX LATCH                              NO ALARM
          A770 T2 PROTECTIVE SWITCH  MAJOR ALARM                        ALARM
          A772 T2 SUB A757                                              NO ALARM
          A775 T2R CHANNEL 7 BIPOLAR OUT                                NO ALARM

          PARAMETERS
          P135 T2ANDBY DEMOD EYE PATTERN                                GOOD

TIME=  4.428

          ALARMS
          A475 T3T NORMAL CHANNEL 8 INPUT                               NO ALARM
          A476 T3T STANDBY CHANNEL 8 INPUT                              NO ALARM
```

TABLE 3-29.   ALARM LISTING   (CONTINUED)

```
          A517 T3T CHANNEL 8 INPUT                              NO ALARM
          A712 T1 NORMAL MAJOR ALARM                            ALARM
          A720 T1 PROTECTIVE SWITCH  MAJOR ALARM                ALARM
          A757 T2 STANDBY BIPOLAR OUT                           NO ALARM
          A775 T2R CHANNEL 7 BIPOLAR OUT                        ALARM

          PARAMETERS
          P136 T2 STANDBY 3 LEVEL VIOLATION DETECTOR            GOOD

TIME=  4.429

          ALARMS
          A475 T3T NORMAL CHANNEL 8 INPUT                       ALARM
          A476 T3T STANDBY CHANNEL 8 INPUT                      ALARM
          A517 T3T CHANNEL 8 INPUT                              ALARM
          A543 T4R NORMAL BIPOLAR OUT                           NO ALARM

          PARAMETERS
          P137 T2 STANDBY FRAME BIT ERROR                       GOOD

TIME=  4.430

          ALARMS
          A543 T4R NORMAL BIPOLAR OUT                           ALARM
          A565 T4R CHANNEL 8 BIPOLAR OUT                        NO ALARM
          A749 T2 STANDBY REFRAME                               NO ALARM

          PARAMETERS

TIME=  4.431

          ALARMS
          A265 T5T NORMAL CHANNEL 8 INPUT                       NO ALARM
          A266 T5T STANDBY CHANNEL 8 INPUT                      NO ALARM
          A307 T5T CHANNEL 8 INPUT                              NO ALARM
          A565 T4R CHANNEL 8 BIPOLAR OUT                        ALARM
          A742 T2R STANDBY MUX                                  NO ALARM
          A771 T2 PROTECTIVE SWITCH MINOR ALARM                 NO ALARM

          PARAMETERS

TIME=  4.432

          ALARMS
          A265 T5T NORMAL CHANNEL 8 INPUT                       ALARM
          A266 T5T STANDBY CHANNEL 8 INPUT                      ALARM
          A307 T5T CHANNEL 8 INPUT                              ALARM
          A333 T6R NORMAL BIPOLAR OUT                           NO ALARM

          PARAMETERS
```

TABLE 3-29. ALARM LISTING (CONTINUED)

```
TIME=  4.433

        ALARMS
        A333 T6R NORMAL BIPOLAR OUT                    ALARM
        A353 W2R T1 RCV BIT STREAM                     NO ALARM
        A355 T6R CHANNEL 8 BIPOLAR OUT                 NO ALARM

        PARAMETERS

TIME=  4.434

        ALARMS
        A353 W2R T1 RCV BIT STREAM                     ALARM
        A355 T6R CHANNEL 8 BIPOLAR OUT                 ALARM
        A411 W2R CHANNEL 8 RCV OUT DATA                NO ALARM

        PARAMETERS

TIME=  4.435

        ALARMS
        A061 W3T CHANNEL 8 INPUT                       NO ALARM
        A411 W2R CHANNEL 8 RCV OUT DATA                ALARM

        PARAMETERS

TIME=  4.436

        ALARMS
        A061 W3T CHANNEL 8 INPUT                       ALARM
        A137 W4R CHANNEL RCV OUT DATA                  NO ALARM

        PARAMETERS

TIME=  4.437

        ALARMS
        A137 W4R CHANNEL RCV OUT DATA                  ALARM

        PARAMETERS

TIME=  4.451

        ALARMS
        A759 T2 20 MS TIMER                            ALARM

        PARAMETERS
```

TABLE 3-29. ALARM LISTING (CONTINUED)

```
TIME=  5.426

        ALARMS
        A754 T2 1 SEC TIMER                                   ALARM

        PARAMETERS

TIME=  5.427

        ALARMS
        A706 T1 1 SEC TIMER                                   ALARM

        PARAMETERS

TIME=  5.428

        ALARMS
        A688 T1 TX XFER STATUS                                ALARM

        PARAMETERS

TIME=  5.429

        ALARMS
        A698 T1 10 MS TIMER FOR TX LATCH                      ALARM
        A699 T1 STANDBY REFRAME                               ALARM
        A721 T1 PROTECTIVE SWITCH MINOR ALARM                 ALARM

        PARAMETERS
        P125 T1ANDBY DEMOD EYE PATTERN                        INACTIVE

TIME=  5.430

        ALARMS
        A692 T1R STANDBY MUX                                  ALARM
        A706 T1 1 SEC TIMER                                   NO ALARM

        PARAMETERS
        P126 T1 STANDBY 3 LEVEL VIOLATION DETECTOR            INACTIVE

TIME=  5.431

        ALARMS

        PARAMETERS
        P127 T1 STANDBY FRAME BIT ERROR                       INACTIVE

TIME=  5.432

        ALARMS
```

TABLE 3-29. ALARM LISTING (CONTINUED)

```
        PARAMETERS
        P129 T1R 3 LEVEL VIOLATION DETECTOR                                INACTIVE

TIME=  5.433

        ALARMS

        PARAMETERS
        P130 T1R FRAME BIT ERROR                                           INACTIVE
```

TABLE 3-29. ALARM LISTING (CONTINUED)

TABLE 3-30. COMPARISON OF ALTERNATIVES

Site	Original # Alarms	SSFSS # Alarms
R7 AB RCVR Pilot		
HDG	7	4
KSL	4	4
STB	12 (+9 flash)	2
SGT	22	8
VHN	2	1
	47 (56)	19
R1A TX Power Failure		
HDG	3 (+1 flash)	0 (+1 flash)
KSL	0 (+4 flash)	0
SGT	0 (+4 flash)	0 (+1 flash)
	3 (12)	0 (2)
W2T Fuse Alarm		
HDG	8	1
KSL	3	0
STB	3	0
SGT	9	1
VHN	1	0
	24	2
W4T Fuse Alarm		
HDG	1	0
SGT	8	1
VHN	7	1
	16	2
W1T Fuse Alarm		
HDG	7	1
SGT	7	1
VHN	1	0
	15	2
R2 AB Rcvr Pilot		
HDG	14	6
SWN	4	1
KSL	13 (+9 flash)	2
STB	3	0
SGT	12	3
VHN	3	1
	49 (58)	13

	Route \ Equip	HDG							SWN		KSL									STB					
		W1T	C1T	C2T	C3T	C4T	T1T	R1T	R2R	R3T	R4R	T2R	C5R	C6T	C7T	C8T	C9T	T3T	R5T	R6R	T4R	T5T	R7T	R8R	T6R
1	HDG→VHN	X(8)					X(7)	X	X	X	X	X(7)						X(8)	X	X	X(8)	X(8)	X	X	X(8)
2	HDG→SGT		X				X(4)	X	X	X	X	X(4)						X(7)	X	X	X(7)	X(7)	X	X	X(7)
3	HDG→SGT			X			X(5)	X	X	X	X	X(5)						X(4)	X	X	X(4)	X(4)	X	X	X(4)
4	HDG→VHN				X		X(6)	X	X	X	X	X(6)						X(3)	X	X	X(3)	X(3)	X	X	X(3)
5	HDG→KSL					X	X(8)	X	X	X	X	X(8)	X												
6	KSL→SGT (FKT)													X				X(1)	X	X	X(1)	X(1)	X	X	X(1)
7	KSL→SGT														X			X(2)	X	X	X(2)	X(2)	X	X	X(2)
8	KSL→SGT (KLN)															X		X(5)	X	X	X(5)	X(5)	X	X	X(5)
9	KSL→SGT																X	X(6)	X	X	X(6)	X(6)	X	X	X(6)
10	SGT→VHN (LKF)																								
11	SGT→VHN (LKF)																								
12	SGT→VHN																								
13	SGT→VHN																								
14	SGT→VHN																								

	Route \ Equip	W1R	C1R	C2R	C3R	C4R	T1R	R1R	R2T	R3R	R4T	T2T	C5T	C6R	C7R	C8R	C9R	T3R	R5R	R6T	T4T	T5R	R7R	R8T	T6T
15	VHN→HDG	X(8)					X(7)	X	X	X	X	X(7)						X(8)	X	X	X(8)	X(8)	X	X	X(8)
16	SGT→HDG		X				X(4)	X	X	X	X	X(4)						X(7)	X	X	X(7)	X(7)	X	X	X(7)
17	SGT→HDG			X			X(5)	X	X	X	X	X(5)						X(4)	X	X	X(4)	X(4)	X	X	X(4)
18	VHN→HDG				X		X(6)	X	X	X	X	X(6)						X(3)	X	X	X(3)	X(3)	X	X	X(3)
19	RSL→HDG					X	X(8)	X	X	X	X	X(8)	X												
20	SGT (FKT)→KSL													X				X(1)	X	X	X(1)	X(1)	X	X	X(1)
21	SGT→KSL														X			X(2)	X	X	X(2)	X(2)	X	X	X(2)
22	SGT (KLN)→KSL															X		X(5)	X	X	X(5)	X(5)	X	X	X(5)
23	SGT→KSL																X	X(6)	X	X	X(6)	X(6)	X	X	X(6)
24	VHN (LKF)→SGT																								
25	VHN (LKF)→SGT																								
26	VHN→SGT																								
27	VHN→SGT																								
28	VHN→SGT																								

NOTES: Numbers within ( ) indicate multiplex channel

▌ - point of origin, point of termination

X - indicates equipment used on route

W - indicates T1WB1

C - indicates CY-104

T - indicates T1-4000

R - indicates Radio, AN/FRC-162

T - after equipment number indicates Transmit

R - after equipment number indicates Receive

		STB				SGT																	VHN								
3T	R5T	R6R	T4R	T5T	R7T	R8R	T6R	C10R	C11R	C12R	C13R	C14R	C15R	C16T	C17T	C18T	C19T	C20T	W2R	W3T	T7T	R9T	R10R	T8R	W4R	C21R	C22R	C23R	C24R	C25R	C26R
(8)	X	X	X(8)	X(8)	X	X	X(8)												X(8)	X(8)	X(1)	X	X	X(1)	X(8)						
(7)	X	X	X(7)	X(7)	X	X	X(7)						X																		
(4)	X	X	X(4)	X(4)	X	X	X(4)			X																					
(3)	X	X	X(3)	X(3)	X	X	X(3)														X(2)	X	X	X(2)		X					
(1)	X	X	X(1)	X(1)	X	X	X(1)	X																							
(2)	X	X	X(2)	X(2)	X	X	X(2)		X																						
(5)	X	X	X(5)	X(5)	X	X	X(5)				X																				
(6)	X	X	X(6)	X(6)	X	X	X(6)					X																			
														X							X(3)	X	X	X(3)			X				
															X						X(4)	X	X	X(4)				X			
																X					X(5)	X	X	X(5)					X		
																	X				X(6)	X	X	X(6)						X	
																		X			X(7)	X	X	X(7)							X

3R	R5R	R6T	T4T	T5R	R7R	R8T	T6T	C10T	C11T	C12T	C13T	C14T	C15T	C16R	C17R	C18R	C19R	C20R	W2T	W3R	T7R	R9R	R10T	T8T	W4T	C21T	C22T	C23T	C24T	C25T	C26T
(8)	X	X	X(8)	X(8)	X	X	X(8)												X(8)	X(8)	X(1)	X	X	X(1)	X(8)						
(7)	X	X	X(7)	X(7)	X	X	X(7)						X																		
(4)	X	X	X(4)	X(4)	X	X	X(4)			X																					
(3)	X	X	X(3)	X(3)	X	X	X(3)														X(2)	X	X	X(2)		X					
(1)	X	X	X(1)	X(1)	X	X	X(1)	X																							
(2)	X	X	X(2)	X(2)	X	X	X(2)		X																						
(5)	X	X	X(5)	X(5)	X	X	X(5)				X																				
(6)	X	X	X(6)	X(6)	X	X	X(6)					X																			
														X							X(3)	X	X	X(3)			X				
															X						X(4)	X	X	X(4)				X			
																X					X(5)	X	X	X(5)					X		
																	X				X(6)	X	X	X(6)						X	
																		X			X(7)	X	X	X(7)							X

FIGURE 3-16. FKV EQUIPMENT USE MATRIX

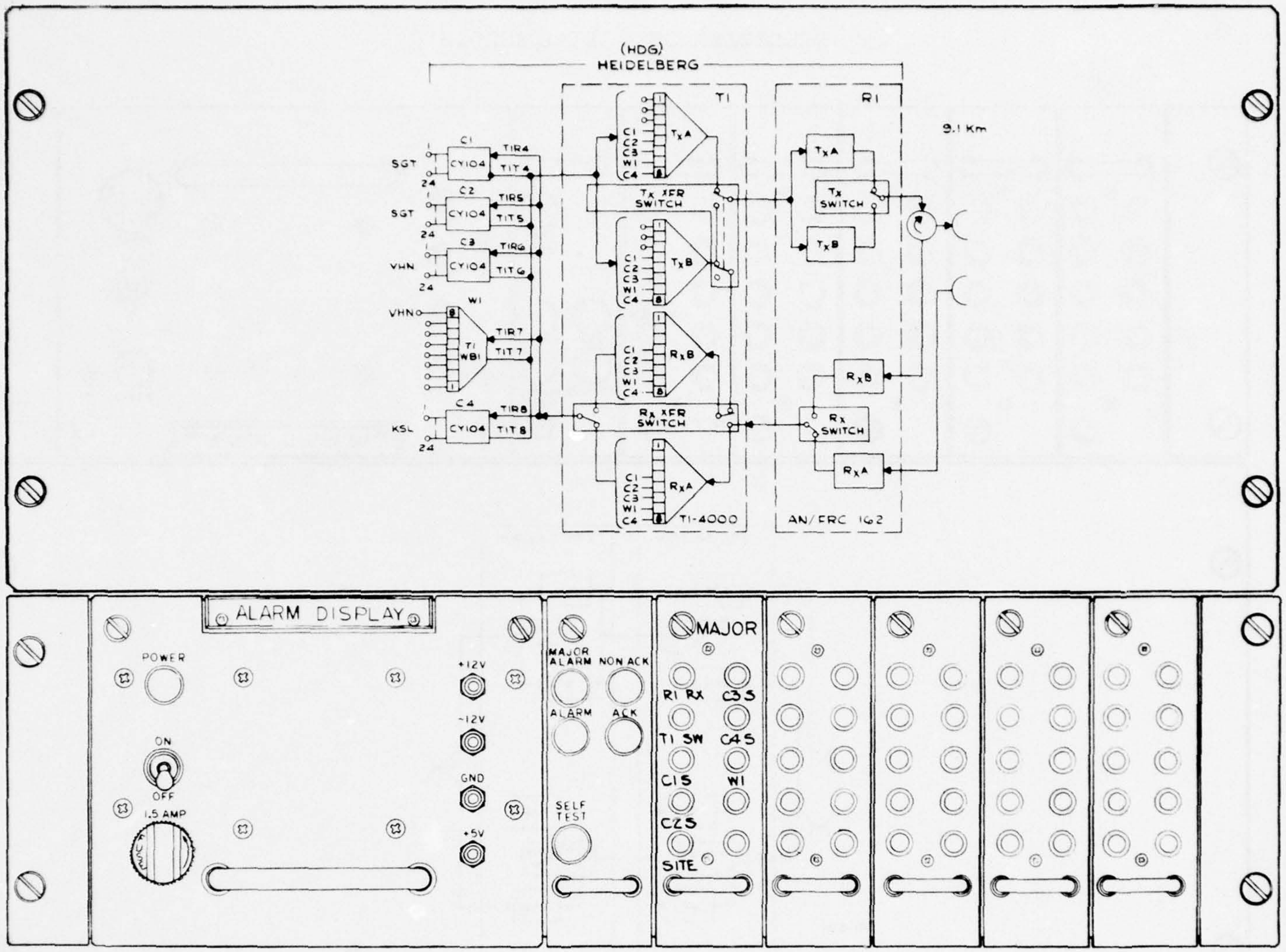


FIGURE 3-17. HEIDELBERG

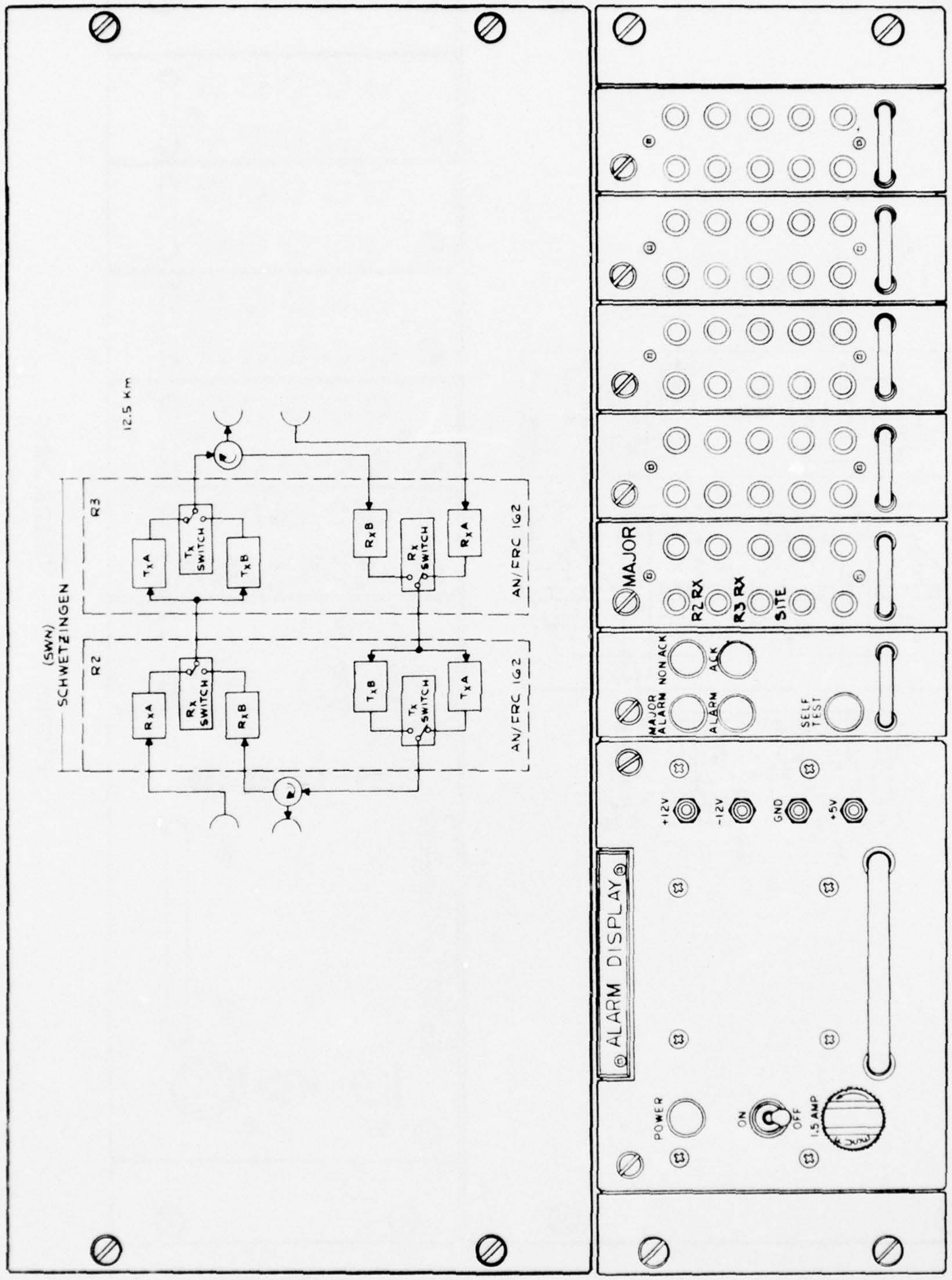


FIGURE 3-18. SCHWETZINGEN

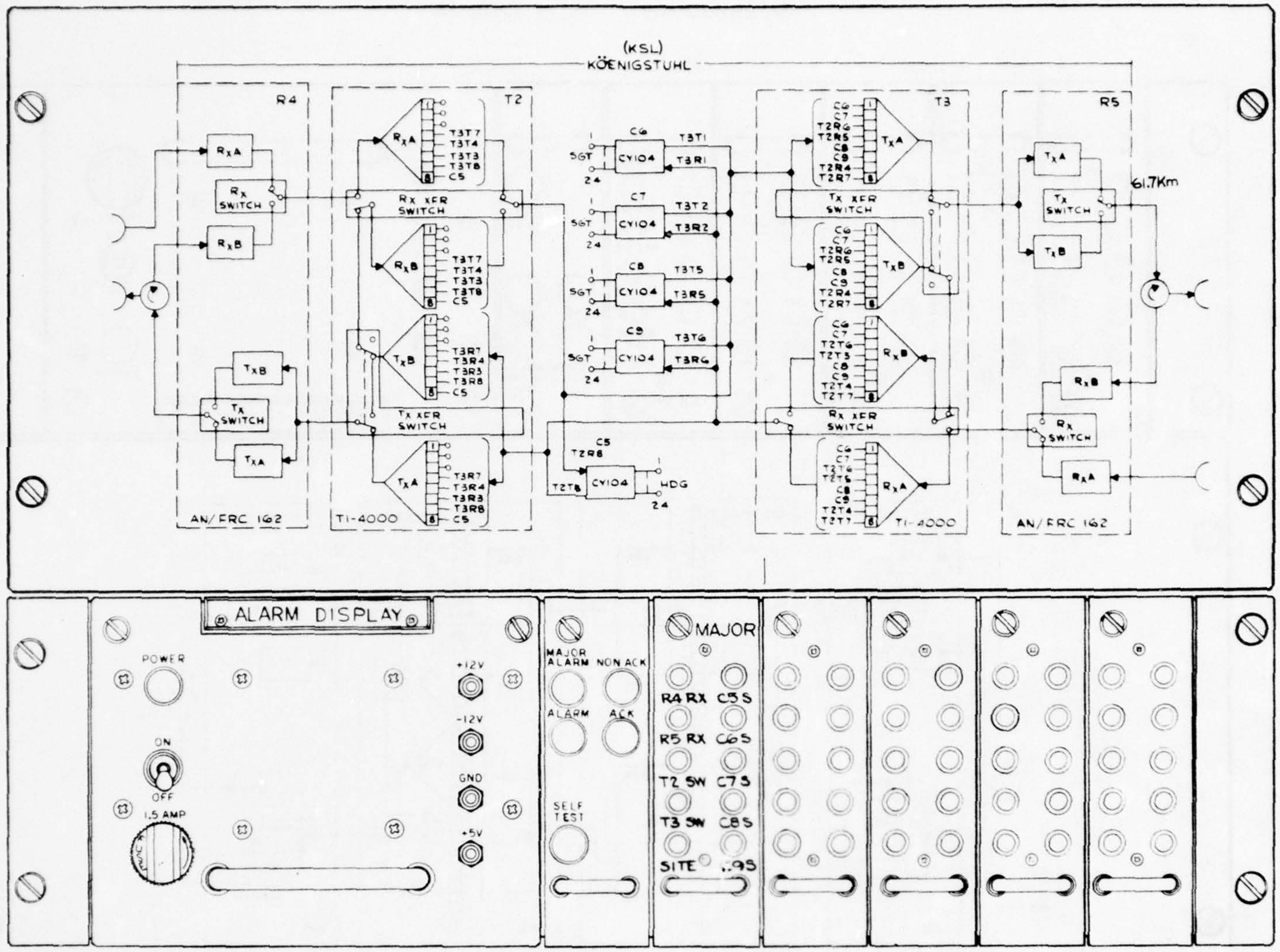


FIGURE 3-19. KOENIGSTUHL

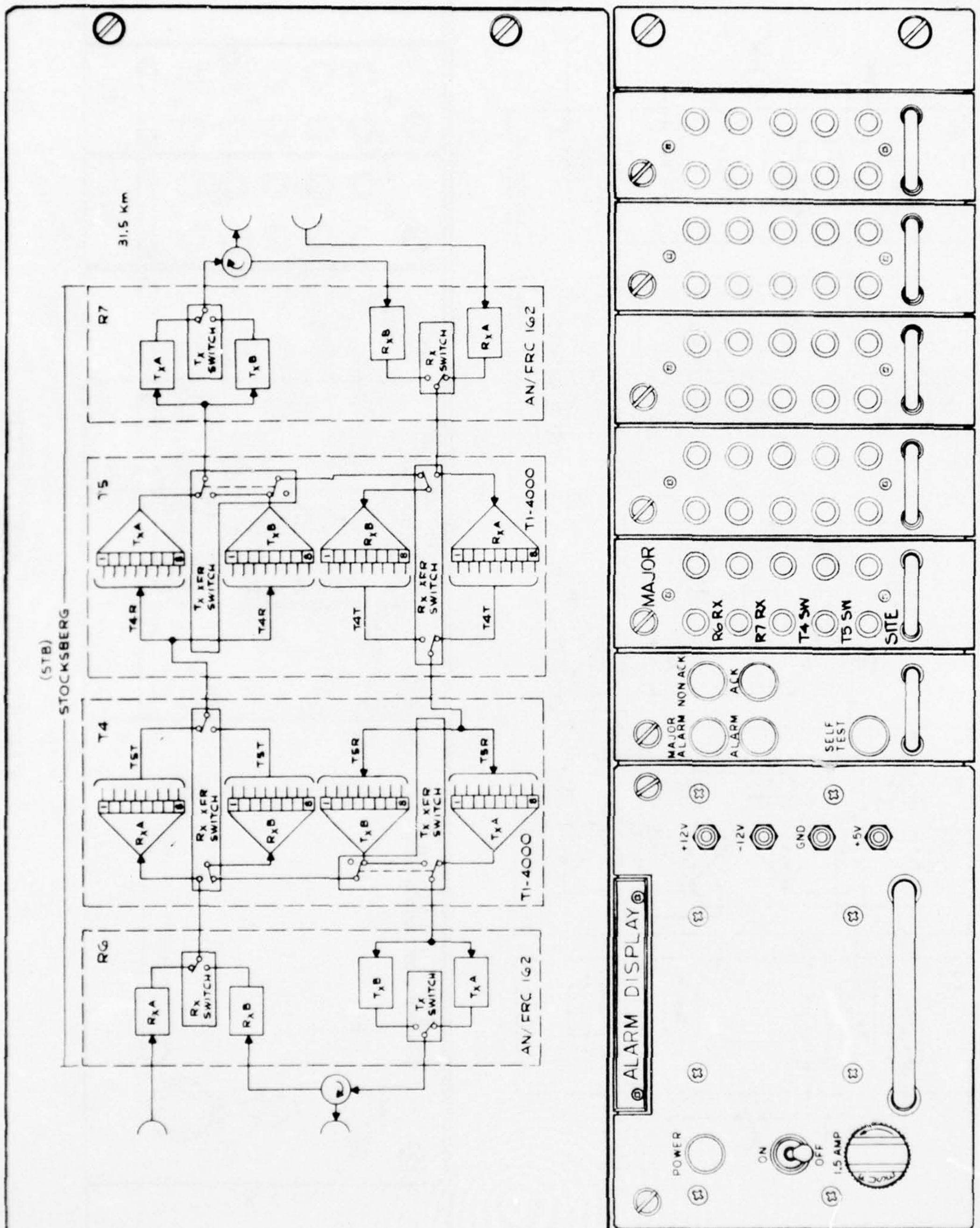


FIGURE 3-20. STOCKSBERG

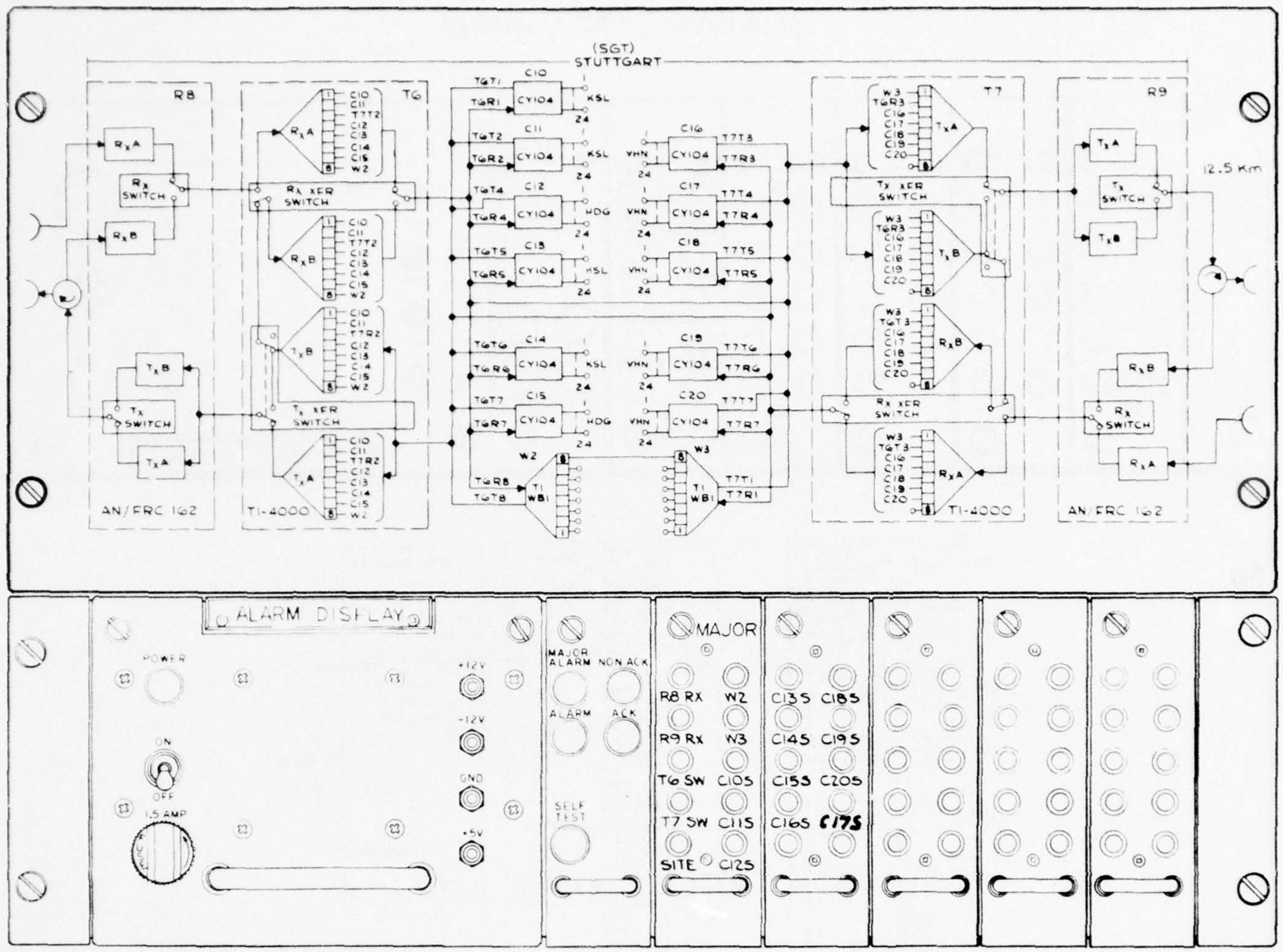


FIGURE 3-21. STUTTGART

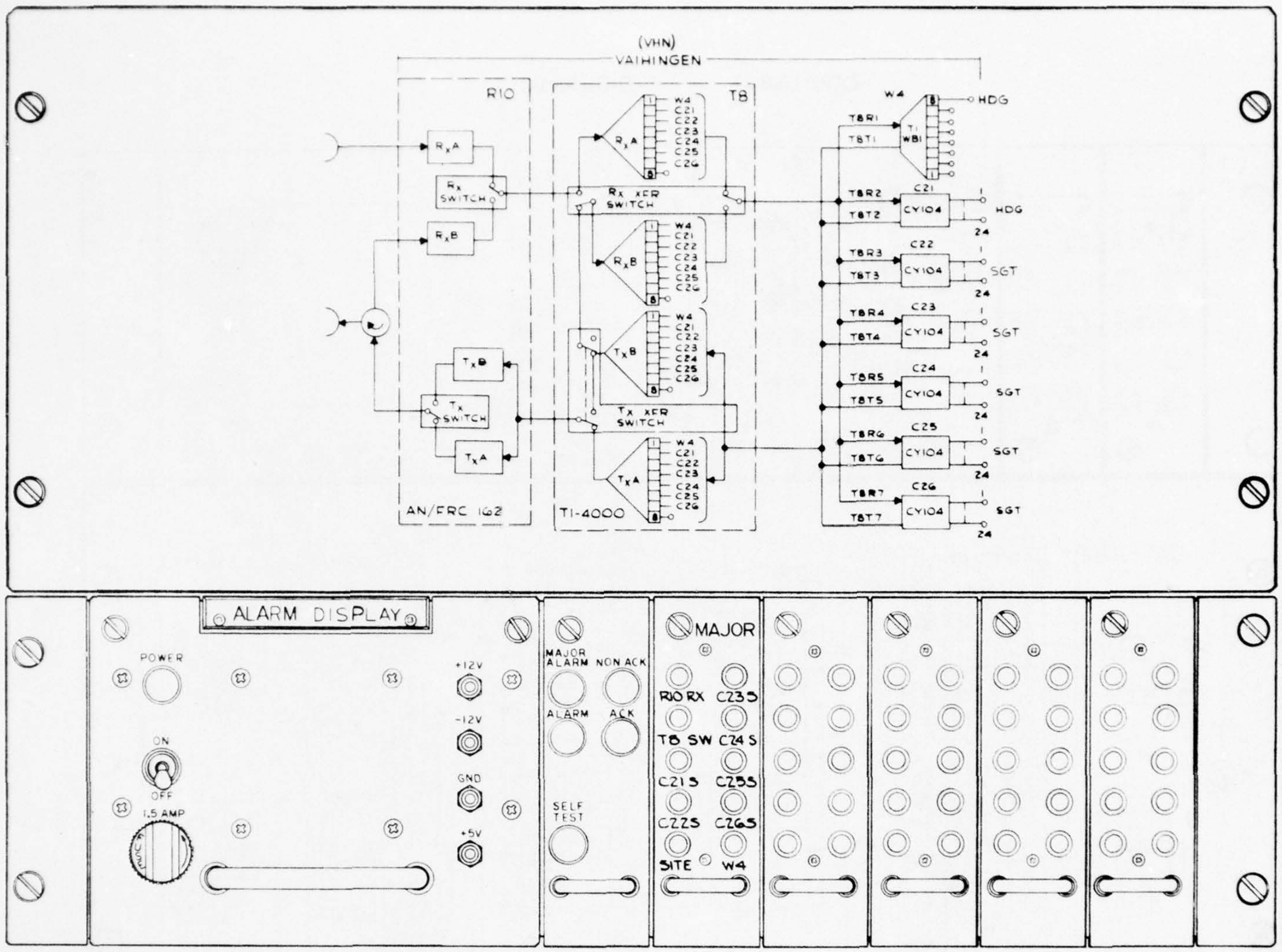


FIGURE 3-22. VAIHINGEN

HDG

1. R1 RADIO Rx
2. T1 SW MAJOR
•3. C1 SERVICE
•4. C2 SERVICE
5. SITE
•6. C3 SERVICE
7. C4 SERVICE
•8. W1 OFFICE

SWN

1. R2 RADIO Rx
2. R3 RADIO Rx
3. SITE

KSL

1. R4 RADIO Rx
2. R5 RADIO Rx
3. T2 SW MAJOR
4. T3 SW MAJOR
5. SITE
6. C5 SERVICE
•7. C6 SERVICE
•8. C7 SERVICE
•9. C8 SERVICE
•10. C9 SERVICE

STB

1. R6 RADIO Rx
•2. R7 RADIO Rx •
3. T4 SW MAJOR
•4. T5 SW MAJOR
5. SITE

SGT

1. R8 RADIO Rx
2. R9 RADIO Rx
•3. T6 SW MAJOR
4. T7 SW MAJOR
5. SITE
•6. W2 OFFICE
7. W3 OFFICE
•8. C10 SERVICE
•9. C11 SERVICE
•10. C12 SERVICE
•11. C13 SERVICE
•12. C14 SERVICE
•13. C15 SERVICE
14. C16 SERVICE
15. C17 SERVICE
16. C18 SERVICE
17. C19 SERVICE
18. C20 SERVICE

VHN

1. R10 RADIO Rx
2. T8 SW MAJOR
•3. C21 SERVICE
4. C22 SERVICE
5. SITE
6. C23 SERVICE
7. C24 SERVICE
8. C25 SERVICE
9. C26 SERVICE
10. W4 OFFICE

FIGURE 3-23. R7 A AND B RADIO Rx (A RECEIVER PILOT • B RECEIVER PILOT)

HDG		SWN	KSL	
1. R1 RADIO Rx	5. SITE	1. R2 RADIO Rx	1. R4 RADIO Rx	6. C5 SERVICE
2. T1 SW MAJOR	6. C3 SERVICE	2. R3 RADIO Rx	2. R5 RADIO Rx	7. C6 SERVICE
3. C1 SERVICE	7. C4 SERVICE	3. SITE	3. T2 SW MAJOR	8. C7 SERVICE
4. C2 SERVICE	8. W1 OFFICE		4. T3 SW MAJOR	9. C8 SERVICE
			5. SITE	10. C9 SERVICE

STB	SGT			
1. R6 RADIO Rx	1. R8 RADIO Rx	6. W2 OFFICE	11. C13 SERVICE	16. C18 SERVICE
2. R7 RADIO Rx	2. R9 RADIO Rx	● 7. W3 OFFICE	12. C14 SERVICE	17. C19 SERVICE
3. T4 SW MAJOR	3. T6 SW MAJOR	8. C10 SERVICE	13. C15 SERVICE	18. C20 SERVICE
4. T5 SW MAJOR	4. T7 SW MAJOR	9. C11 SERVICE	14. C16 SERVICE	
5. SITE	5. SITE	10. C12 SERVICE	15. C17 SERVICE	

VHN	
1. R10 RADIO Rx	6. C23 SERVICE
2. T8 SW MAJOR	7. C24 SERVICE
3. C21 SERVICE	8. C25 SERVICE
4. C22 SERVICE	9. C26 SERVICE
5. SITE	● 10. W4 OFFICE

FIGURE 3-24. W3T OR W4T FUSE ALARM

AD-A033 538 HONEYWELL INC ST PETERSBURG FLA AEROSPACE DIV F/G 17/2
ATEC DIGITAL ADAPTATION STUDY. VOLUME I. FKV REQUIREMENTS FOR P--ETC(U)
OCT 76 T R ARMSTRONG, A K BLOUGH F30602-75-C-0282
UNCLASSIFIED 476-13656-VOL-1 RADC-TR-76-302-VOL-1 NL

3 OF 5
ADA033538

HDG

1. R1 RADIO Rx
2. T1 SW MAJOR
3. C1 SERVICE
4. C2 SERVICE
5. SITE
6. C3 SERVICE
7. C4 SERVICE
8. ●8. W1 OFFICE

SWN

1. R2 RADIO Rx
2. R3 RADIO Rx
3. SITE

KSL

1. R4 RADIO Rx
2. R5 RADIO Rx
3. T2 SW MAJOR
4. T3 SW MAJOR
5. SITE
6. C5 SERVICE
7. C6 SERVICE
8. C7 SERVICE
9. C8 SERVICE
10. C9 SERVICE

STB

1. R6 RADIO Rx
2. R7 RADIO Rx
3. T4 SW MAJOR
4. T5 SW MAJOR
5. SITE

SGT

1. R8 RADIO Rx
2. R9 RADIO Rx
3. T6 SW MAJOR
4. T7 SW MAJOR
5. SITE
6. ●6. W2 OFFICE
7. W3 OFFICE
8. C10 SERVICE
9. C11 SERVICE
10. C12 SERVICE
11. C13 SERVICE
12. C14 SERVICE
13. C15 SERVICE
14. C16 SERVICE
15. C17 SERVICE
16. C18 SERVICE
17. C19 SERVICE
18. C20 SERVICE

VHN

1. R10 RADIO Rx
2. T8 SW MAJOR
3. C21 SERVICE
4. C22 SERVICE
5. SITE
6. C23 SERVICE
7. C24 SERVICE
8. C25 SERVICE
9. C26 SERVICE
10. W4 OFFICE

FIGURE 3-25. W1T OR W2T FUSE ALARM

HDG

1. R1 RADIO Rx
2. T1 SW MAJOR
3. C1 SERVICE
4. C2 SERVICE
5. SITE
6. C3 SERVICE
7. C4 SERVICE
8. W1 OFFICE

SWN

1. R2 RADIO Rx
2. R3 RADIO Rx
3. SITE

KSL

1. R4 RADIO Rx
2. R5 RADIO Rx
3. T2 SW MAJOR
4. T3 SW MAJOR
5. SITE
6. C5 SERVICE
7. C6 SERVICE
8. C7 SERVICE
9. C8 SERVICE
10. C9 SERVICE

STB

1. R6 RADIO Rx
2. R7 RADIO Rx
3. T4 SW MAJOR
4. T5 SW MAJOR
5. SITE

SGT

1. R8 RADIO Rx
2. R9 PADIO Rx
3. T6 SW MAJOR
4. T7 SW MAJOR
5. SITE
6. W2 OFFICE
7. W3 OFFICE
8. C10 SERVICE
9. C11 SERVICE
10. C12 SERVICE
11. C13 SERVICE
12. C14 SERVICE
13. C15 SERVICE
14. C16 SERVICE
15. C17 SERVICE
16. C18 SERVICE
17. C19 SERVICE
18. C20 SERVICE

VHN

1. R10 RADIO Rx
2. T8 SW MAJOR
3. C21 SERVICE
4. C22 SERVICE
5. SITE
6. C23 SERVICE
7. C24 SERVICE
8. C25 SERVICE
9. C26 SERVICE
10. W4 OFFICE

FIGURE 3-26. R1A Tx POWER FAILURE (NO ALARMS - SWITCH TO R1B)

HDG

1. R1 RADIO Rx
●2. T1 SW MAJOR
●3. C1 SERVICE
●4. C2 SERVICE
5. SITE
●6. C3 SERVICE
●7. C4 SERVICE
●8. W1 OFFICE

SWN

●1. R2 RADIO Rx
2. R3 RADIO Rx
3. SITE

KSL

1. R4 RADIO Rx
2. R5 RADIO Rx
●3. T2 SW MAJOR
4. T3 SW MAJOR
5. SITE
●6. C5 SERVICE
7. C6 SERVICE
8. C7 SERVICE
9. C8 SERVICE
10. C9 SERVICE

STB

1. R6 RADIO Rx
2. R7 RADIO Rx
3. T4 SW MAJOR
4. T5 SW MAJOR
5. SITE

SGT

1. R8 RADIO Rx
2. R9 RADIO Rx
3. T6 SW MAJOR
4. T7 SW MAJOR
5. SITE
●6. W2 OFFICE
7. W3 OFFICE
8. C10 SERVICE
9. C11 SERVICE
●10. C12 SERVICE
11. C13 SERVICE
12. C14 SERVICE
●13. C15 SERVICE
14. C16 SERVICE
15. C17 SERVICE
16. C18 SERVICE
17. C19 SERVICE
18. C20 SERVICE

VHN

1. R10 RADIO Rx
2. T8 SW MAJOR
●3. C21 SERVICE
4. C22 SERVICE
5. SITE
6. C23 SERVICE
7. C24 SERVICE
8. C25 SERVICE
9. C26 SERVICE
10. W4 OFFICE

FIGURE 3-27. R2 RADIO Rx (A RECEIVER PILOT ● B RECEIVER PILOT)

3.9.2 Multiport Simulation

A primary requirement of nodal control monitoring software is to provide for remote sensor data collection. This involves transmitting commands to and receiving responses from MACs and MADs located throughout the FKV network. Three data collection techniques were considered in this study.

a. Single line controller. MACs and MADs have been designed to operate in a daisy chain or tandem fashion. Each device will not respond unless it recognizes its address. This allows a number of MACs or MADs to be connected to a single full duplex line and controlled in software by means of a single line controller. This technique is inexpensive to implement but is relatively slow because communication must be handled in a serial fashion. The software implementation of the data collection is rather straightforward. Inputs and Outputs are handled under interrupt control and the interrupt processing time (approximately 200 usec per character) is small compared to the time between interrupts (approximately 67 ms at 150 baud). This allows ample time for performing analysis tasks while communication is going on.

b. Multiline controller with data concentrator. This allows MACs and MADs to operate in parallel. Each device is controlled in software by means of a multiport controller with input and output handled by a Data Concentrator. This technique has been used successfully in the CPMAS, but is not considered cost effective. A separate processor is required for the Data Concentrator (DC) to provide storage for programs which will control the DC and also to act as a buffer between the collected data and the central processor which is used for computation and analysis. Additionally an Inter-Computer Control Unit (ICCU) is required to provide control of processor to processor high speed data transfer.

c. Multiport controller without data concentrator. Again, in this method MACs and MADs operate in parallel. Each device is controlled in software by means of a multiport controller with input and output handled by the single processor which must also perform analysis tasks while communications are going on. Because of the difficulty in determining if ample

time is allowed for analysis tasks, a simulation was undertaken to demonstrate that timing considerations could be met.

The program was designed to use as much of the FKV Simulation Software as possible. The only basic change was a redesign of the alarm and parameter generation segment (Figure 3-15) to perform calculations necessary for this application.

In essence, alarm and parameter generation simulates the transfer of information from the processor to the controller and finally to the MAC or MAD and the response from the MAC or MAD thru the controller to the processor using appropriate time delays between each step (see Figure 3-28). Simulating four interrupt driven controllers to communicate with the six sites (see Figure 3-29), we can determine the amount of time needed for processing controller interrupts. This also indicates how much time is then available for analysis tasks and whether this time is adequate.

3.9.2.1 Results

The simulation run described herein was run for a simulated time of 11.268 seconds. It was found that during this period of time, 44.878 milliseconds of central processor time was required to process interrupts resulting from maximum usage of the four remote devices.

3.9.2.2 Conclusion

The use of four remote devices connected through a multiline controller to a CPU as described herein presents no severe time constraints. Ample time is available by the CPU for carrying out analysis tasks. However, within the constraints of cost effectiveness and practicality a Single Line Controller (SLC) is recommended, since the SLC provides an adequate system parameter scan (Paragraph 3.9.2a) rate at minimal cost and complexity.

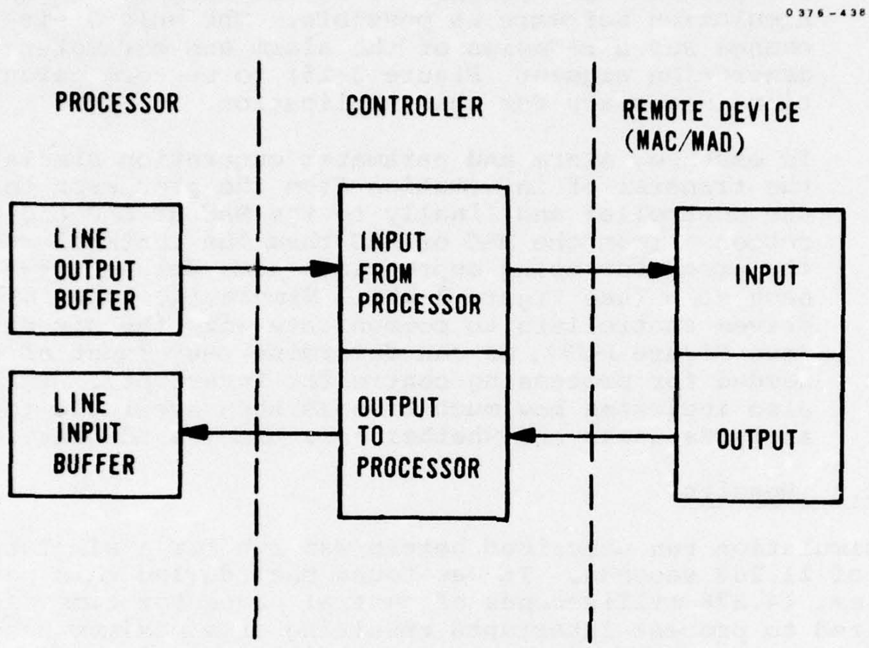


FIGURE 3-28. SIMULATION OF INFORMATION TRANSFER FOR MULTIPORT CONTROLLER WITHOUT DATA CONCENTRATOR

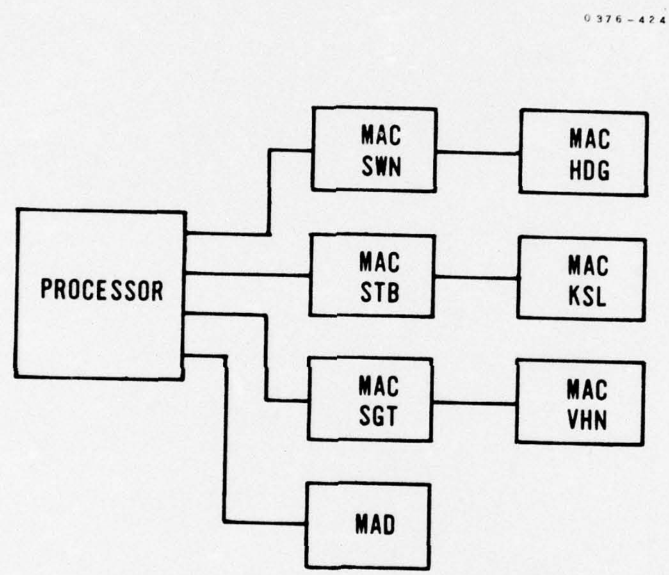


FIGURE 3-29. SIMULATION OF COMMUNICATION WITH SIX SITES FOR MULTIPORT CONTROLLER WITHOUT DATA CONCENTRATOR

Section 4

CONCLUSIONS

4.1 MONITOR POINTS

The objective of the activity documented in Volume I of this report was to identify what monitor points should be collected by a monitoring system to provide performance assessment, fault isolation, and trend analysis of the FKV digital transmission system. The study and analysis performed has resulted in a list of recommended monitor points for each FKV system equipment plus the radio baseband and VF signal interfaces.

The final recommended monitor points are listed in Table 4-1. The generic signal types which a monitor system must measure and collect are listed in Table 4-2.

Tables 4-1 and 4-2 identify the monitor point information which a monitoring system must be capable of collecting. The actual method of data collection is a function of the monitoring system approach and the equipment used to perform the measurements.

4.2 MONITOR SYSTEM APPROACH

The monitoring system approach recommended for the FKV system is basically a two level system. Level 1 is a Sudden Service Failure Sensing System which is an equipment alarm scanner system with rapid response to a loss of system service at all levels and operates independently of the Level 2 computer system. Level 2 is a computer driven system which performs the functions of PA/FI/TA for the entire system through monitor point data collection and analysis.

The monitoring system provides performance assessment at both the system and equipment levels. Fault isolation addresses both degradation and fault isolation to the equipment level. Trend analysis provides a statistical summary of system and equipment operation.

TABLE 4-1. MONITOR POINT LIST

EQUIPMENT	ALARM CONDITION
RADIO:	
Transmitter Problem Tx A Tx B	• RF power below threshold • AFC voltage beyond normal control range • Pilot frequency level below threshold
Receiver Problem Rx A Rx B	• Local oscillator loses phaselock with crystal controlled reference • Received signal below preset threshold
Radio Rx: (Pilot A AND B)	• Rx Pilot lost in both receivers
Rx Squelch Rx A Rx B	• Rx AGC below preset threshold in both receivers
Maintenance A Maintenance B	• Status indicator controlled by manually set switches
RSL Rx A Rx B	• Received signal level. Alarms upon violation of programmable threshold.
Tx-Rx In-Service (Unit A or B)	• Operational status indicator
Power Supply Voltages, PS1-8 (optional)	• Voltage measurement with programmable threshold.
BASEBAND:	
Radio Baseband Eye Unit A Unit B (Noise, Amplitude, Bursts)	• System performance measurement provides eye margin (noise margin in dB to PCM threshold) and baseband amplitude burst detection. Alarms upon detection of programmable threshold.

TABLE 4-1. MONITOR POINT LIST (CONTINUED)

EQUIPMENT	ALARM CONDITION
T1-4000:	
Switch, Major	• Transfer attempt failed • Standby multiplexer loses synchronization when transferred • Remote alarm • Power loss; Switch unit or Standby multiplexer
Switch, Minor	• Receiver or Transmitter transferred • Receiver or transmitter automatic transfer disabled • Switch Unit power loss • Standby multiplexer loses synchronization
Major Alarm Unit A Unit B	• +20 Vdc loss • Remote alarm • Loss of receiver main frame synchronization • Loss of receiver control reframe synchronization
Main Frame Bit Error Unit A Unit B	• System performance measurement from which BER is calculated. Alarms upon detection of programmable threshold.
Control Reframe Unit A Unit B	• System performance measurement provides a latched alarm upon detection
Tx-Rx In-Service (Unit A or B)	• Operating status indicator
Power Supply Voltages, PS1-5 (optional)	• Voltage measurement with programmable threshold
Maintenance A Maintenance B	• Status indicator controlled by manually set switches

TABLE 4-1. MONITOR POINT LIST (CONTINUED)

EQUIPMENT	ALARM CONDITION
T1WB1:	
Office	• Remote Alarm • Local alarm • Bipolar errors in receiver • Fuse alarm • Loop alarm • Outgoing alarm cut-off switch • No power
Reframe	• Multiplexer loses frame synchronization
Maintenance	• Manually controlled by equipment switch
Frame Bit Error	• System performance measurement from which BER is calculated. Alarms upon violation of programmable threshold.
Power Supply Voltages, PS1-6 (optional)	• Voltage measurement with programmable threshold
CY-104:	
Service	• Loss of power • Loop alarm • Remote alarm • Loss of frame synchronization for more than 800 milliseconds • Loss of full duplex operation • Local
Remote	• Fuse alarm • Loss of frame synchronization for more than 800 milliseconds • Far end not passing valid data
VOICE FREQUENCY:	
Average Power in dBm (AV)	• System performance measurement
Signal to Noise (2600 Hz)	• System performance measurement

TABLE 4-2. MONITORED SIGNAL TYPES

SIGNAL TYPE	COMMENT
Two state relay contact closure	• Detect steady state • Detect transients
DC Voltage	• Measure voltages from 100mVdc to 10Vdc
Radio Baseband	• Measure eye pattern parameters noise amplitude bursts
Digital Signal Pulses	• Count events per unit time (EPUT) • Provide resettable latch per unit time 300 nanosecond signal interface at TTL levels
Voice Frequency	• Per PATE (IQCS configuration)

BIBLIOGRAPHY

These tabulated documents are among those which provided reference material for the accomplishment of the Digital Adaptation Study. Additional specific in-text references are recorded in several instances within the body of the Report.

Item Number	Document Name or Description
1	PSB 6004 - "Digital Multiplex Description, Operation and Theory of Operation", Issue 4/73. (T1-4000)
2.	PSB 6005 - "Digital Multiplexer Installation and Maintenance", Issue 4/72. (T1-4000)
3.	PSB 6018 - "Vicon 4030 First Level Multiplexer Protection Switch", Issue 1/75. (T14000)
4.	PSB 6020 - "First Level Digital Multiplex Equipment", Issue 12/74. (T14000)
5.	PSB 6014 - "5200 Wideband Data Terminal Description Operation and Theory of Operation", Issue 10/73. (T1WB1)
6.	PSB 6015 - "5200 Wideband Data Terminal - Installation and Maintenance", Issue 10/73. (T1WB1)
7.	PSB 6000 - "D2 Terminal Description Operation and Theory of Operation", Issue 4/73; Reprint 3/74. (CY104)
8.	PSB 6001 - "D2 Terminal Installation and Maintenance", Issue 4/73 and Issue 8/73. (CY104)
9.	Defense Communications Engineering Center Technical Report No. 3-74, "Digital Transmission System Design". March 1974.
10.	"System Engineering Plan, FKV Project" - Vol. I, prepared by Raytheon-Europe Electronics Company for U. S. Army Communications Systems Agency, August 1974.

Item Number	Document Name or Description
11.	Army Manual IM-11-5820-836-13" - Operator Organizational and Direct Support Maintenance Manual for Radio Set AN/FRC-162(V)". Volume I-III.
12.	DNSF-TR73-100 - "DCS Operational Test and Evaluation of PCM/TDM Equipment; Phase I Testing", Second Printing; June 1975. HQAFCS/EPES.
13.	DCEOH700-1 - "Performance Monitors for Digital Communications Systems". June 1973.
14.	DCEOH700-1A - "Performance Monitors for Digital Communications Systems - Summary"; June 1973.
15.	"Digital Transmission in Evaluation Project RDS-80-G Test Final Report". February 1975.
16.	"Digital Transmission Evaluation Project RDS-80 Test Final Report". March 1975.
17.	"Digital Transmission Evaluation Project MW-518 (QPSK) Test", Interim Report. December 1974.
18.	CCC-SR-75-DTEP-003 - "Digital Equipment Survey Summary Report". January 1975.
19.	OT Technical Memorandum 75-194 - "Measurement of Interference Effects Between TDM-FM and FDM-FM Microwave Systems". March 1975.
20.	OT Technical Memorandum 74-182 - "AN/FRC-80(V)3 Retune and Time Division Multiplex Interface Investigation".
21.	"Test Plan for Evaluation of FKV Pilot Digital System.
22.	"Application of Pulse Code Modulation (PCM) Time Division Multiplex (TDM) and Digital Transmission in the DCS" DCA/DCEO. 7 January 1972.
23.	Foerster, W. and Pandori, D. R. "Circuit Quality Monitor - Final Technical Report". ECOM-0271-3 for Contract DAAB07-71-C-0271 by Philco Ford, August 1973.

Item Number	Document Name or Description
24.	DNSF-TR-75-102 - "Digital Communication System Offset Threshold Monitor"; April 1975 HQ AFCS/EPES.
25.	DNSF-TR-75-101 - "Digital Communications System Improved Offset Timing Monitor; March 1975 HQ AFCS/EPES.
26.	DNSF-TR-75-100 - "Radio Service Channel Techniques in a Digital Communications System"; March 1975 HQ AFCS/EPES.
27.	Leon, B. J., Hammond, J. L., Bode, R. B., and Sears, W. E. "Performance Monitors for Digital Communications Systems - Part II". TR-EE-74-33 School of EE, Purdue University, August 1974.
28.	523-0699635-001A3M - "Transmission of Pulse Code Modulation on DCS Microwave Radio and Optimization Test"; Collins Radio, 10 September 1973.
29.	Supplement to Systems Engineering Plan, Volume I - "FKV Project"; Contract DAAB07-74-C-0210, CDRL Item N001 prepared by Raytheon-Europe for USACAS, 15 January 1975.
30.	RADC-TR-73-7 - "Line-of-Sight Wideband Propagation-Interim Technical Report"; CNR, Inc. sponsored by DARPA-RADC Contract F30602-73-C-0013; January 1973, RADC-TR-73-7, (755922), TR-73-167, (762939).
31.	RADC-TR-XXX - "Final Technical Report - Adaptive Channel Measurement Study"; CNR, Inc. for RADC Contract F30602-74-C-0283; March 1975, RADC-TR-75-243, (A018764).
32.	RADC-TR-73-167 - "Final Technical Report - Line of Sight Wideband Propogation", CNR Inc. for RADC Contract F30602-73-C0013; May 1973, RADC-TR-76-167, (762939).
33.	RADC-TR-74-330 - "Final Report - Line-of-Sight Techniques Investigation"; CNR, Inc. - RADC Contract F30602-73-C-0244; January 1975, RADC-TR-74-330, (A006104).
34.	Hanlon, R. C., Reuter, C. D., "Signal Degradation Monitoring for a Digital Transmission System", University of Kansas Master's Thesis; April 1973.
35.	Digital Transmission Evaluation Project (DTEP) Letter Report: "Engineering Analysis of VICOM 4000 Series Digital Multiplexer Baseline Test Results"; ACCC-CED-DTEP-LR.

Item Number	Document Name or Description
36.	RADC-TR-75-95 - "Equivalence Measurement Studies - Final Report", Volumes I and II; April 1975, Vol I, (A010004), Vol II, (A010005).
37.	RADC-TR-75-115 - "Performance Evaluation of the TD 968(B) Pulse Code Modulation Multiplexer"; In-house Interim Report; April 1975, (B004708).
38.	DNSF-TR-75-105 - "Operational Test and Evaluation of PCM/TDM System Parameters VF Channels Testing", HQAFCS (EPES) Digital Network Systems Facility; July 1975.
39.	HA6-08-54N-01 - "Category I Test Report: Formal Qualification Tests for Systems (Subsystems of The Performance Monitor and Assessment System AN/GYM-12(V)(XW)"; September 1975.
40.	CP75000855 - "Contract End Item Detail Specification: Computer Programs, Central Processor of the AN/GYM-12(V)(XW)"; X Volumes; May 1975.
41.	HA 4-1-14N-01 - "System Service Technical Manual for the CPMAS AN/GYM-12(V)(XW) and Operational and Maintenance Hnadbook; RDT&E Equipment Manual for the Nuclear Subsystem"; IV Volumes.
42.	HA 4-2-15F-01 - "Operational and Maintenance Handbook; RDT&E Equipment Manual for the In-Service-Out-of-Service Quality Control System (I/OQCS) of the CPMAS AN/GYM-12(V)(XW)"; II Volumes.
43.	Sims, Robert L. et al; "Digital Microwave Transmission System" AD/A-002 839; Philco Ford Corporation; November 1974.
44.	Russell, Capt. Steven S. and Eller, Capt. Guy E.; "Performance of Selected Quasi-Analog, Synchronous and Non-Synchronous Data Transmission Schemes on Non-Error Free Digital TDM Links" (draft).
45.	AD902187L; "DCA Applicability of PCM/TDM and Digital Transmission in the DCS"; 7 January 1972.
46.	AD902188L; "Appendix C - PCM/TDM and FDM Multiplex Plans for Portions of the European DCS".

Item Number	Document Name or Description
47.	Jones, Norman G. et al; "Microwave Data Transmission Test Program - QPSK Modems"; Philco Ford Corporation; November 1974.
48.	CED-75-ER-016; "FKV System Degradation Test Program"; (no date).
49.	Draft Report No. 1; "Study of System Control Procedures for All-Digital Networks"; prepared for DCA/DCEO by Data Transmission Company (DATRAN); 6 May 1975.

Appendix A1

MONITOR POINT RATING BASIS

A1-1 RATING CATEGORIES

To provide a quantitative means of relative comparison of candidate monitor points, rating values have been assigned for three basic categories:

- Usefulness
- Availability
- Processing

A 4-3-2-1 scaling is used for each of the categories. The ultimate integration and usage of the ratings within a weighted selection matrix is described in Section 3 of this volume.

The following data from Section 3 recaps the definitions of the rating classifications and defines the meaning of individual rating values in support of the data tabulations in Appendices A2, A3, A4 and A5.

A1-2 RATING SYSTEM DEFINITIONS

A1-2.1 Usefulness

Necessary or Very Useful; Weight Factor: (4)

Absolutely required, cannot be done without or, subjectively, regarded as being of a high degree of service in the area of performance assessment of fault isolation, as the case may be.

For example, the output of the three level violation detector in the T1-4000 multiplexer is given a rating of 4 for performance assessment as this is one of the parameters which may be processed to yield a presumptive measure of the BER on the link from the digital transmitter encoder of the high order multiplexer, through the radio link, through the digital data stream reconstruction in the high order multiplexer receiver.

Useful (3)

Not believed to be necessary but being regarded as adding significant information to, or considerably simplifying, the tasks of performance assessment or fault isolation.

Parameters in this range are best rated by comparison to the upper and lower bounds of this range which are the ratings of 4 and 2.

For example, the three level partial response input to the Tl-4000 is given a rating of 3 for fault isolation. This is due to the fact that while loss of input to the multiplexer receiver is a valuable piece of information for fault isolation, it is not necessary since this condition could be diagnosed from other alarms. Specifically, the FM subcarrier demodulator alarm in the radio system and the loss of multiplexer synchronization and/or 50 percent main frame bit errors would indicate loss of baseband output from the radios. Obviously, however, an activity monitor on the analog input to the multiplexer would simplify the fault isolation process.

Somewhat Useful (2)

Parameters in this rating are considered somewhat useful for fault isolation within an equipment but are considered to be of little value for system level performance assessment or fault isolation, given that higher valued monitor points are available.

For example, the Tl-4000 receiver AGC control signal is given a rating of 2 for fault isolation. Monitoring this signal adds some information to the problem of fault isolation within the equipment but since the AGC gain is not expected to vary significantly with variations in the RF signal, its contribution is of little value for system performance assessment or fault isolation.

Another example of a fault isolation rating of 2 is the Tl-4000 multiplexer derived clock. An activity monitor on this clock would contribute some information if the clock failed but a multiplexer receiver failure (due to the clock failure or another failure) would be manifest in numerous other higher valued monitor points such as main frame bit errors, main reframe, and control reframe.

Not Useful (1)

Parameters in this category are deemed to contribute no significant additional information to the process of performance assessment or fault isolation.

For example, presence or absence of a clock signal internal to an equipment contributes nothing to performance assessment of that equipment.

Al-2.2 Availability

Externally Available with No Buffer (4)

Signals in this category are provided by the equipment manufacturer as monitor points for external monitoring equipment.

Typically the signals take the form of relay contact closures, examples being the major alarms in the radio system.

Card Connector with No Buffering (3)

These signals are available at the connector level and are not expected to require electrical buffering before being inputted to the ATEC monitoring device which may be remotely located.

Examples are dc output voltages and signals which interface between various equipment such as between the radio and Tl-4000.

Card Connector with Buffering (2)

These signals are available at the connector level but require buffering at the extraction or connection point in order that the internal signal is not loaded by wiring capacitance or contaminated by noise.

Examples are internal TTL signals which are employed by the multiplexers.

Internal to Circuit Board (1)

These signals must be accessed at the circuit board level, necessitating a wire from the access point to a card connector. In most cases, since the signal is TTL or low level analog, buffering is required.

An example of such a signal is an internal phase lock loop control voltage which is only available on the emitter of a transistor.

Al-2.3 Processing

No Processing Required (4)

No special software or hardware processing required before the parameter is inputted to existing ATEC hardware/software for further operations.

Examples of this category are contact closure alarms.

Software Processing Only (3)

Parameters in this category require only ATEC software modifications prior to processing by existing ATEC software.

The Tl-4000 receiver AGC control signal is an example since it is a low bandwidth analog signal which can be input to the computer by means of existing ATEC hardware but which will require the development of new software to analyze the signal for performance assessment and trending.

Hardware Processing Only (2)

Parameters in this category require processing by specialized hardware before they are in a form suitable for processing by existing

ATEC software or by existing ATEC software with minimal change.

Examples are error rate counters or analog and digital activity indicators.

It should be noted that buffering is not considered to be hardware processing.

Software and Hardware Processing (1)

Parameters in this category not only require that additional software be developed but also require that complex or specialized hardware be developed.

An example is the radio receiver baseband waveform comparison which would require highly specialized hardware as well as specialized software for subsequent processing and extraction of the desired signal characteristics.

Appendix A2

CY-104 PCM/TDM

A2-1 CY-104 PCM/TDM OPERATIONAL DESCRIPTION

A2-1.1 Introduction

The CY-104 is made up of three subsystems: the VICOM D2 channel bank, the KG-34 crypto subsystem, and the HN-74 signal interface and control unit. Each of these three equipments is packaged in a TEMPEST type cabinet which means that the signals available for performance monitoring and assessment are restricted. The TEMPEST design imposes the constraint that every signal exiting the device must be properly filtered and conditioned. Thus, unless alarm signals have been included in the TEMPEST design, they are not available for use in performance monitoring. The only alarms available from the CY-104 are the Service Alarm and the Remote Alarm. Fortunately, from the standpoint of performance monitoring, the CY-104 may not be the primary multiplex in further upgrades towards a digital DCS. According to published DCA plans, the CY-104 will be replaced by a commercial D3 channel bank in Phase I of the DEB upgrade.

In this section, the VICOM D2 channel bank will be discussed in detail for the reason that it is the main subsystem of the CY-104 and will probably remain the primary or first level multiplex in future digital upgrade projects.

A2-1.2 VICOM D2

The VICOM D2 channel bank time division multiplexes and pulse code modulates 24 VF signals (including signalling) into a single 1.544 Mb/s bipolar pulse stream. This pulse stream is then transmitted to a far end terminal where the reverse operation is performed, that is, the signal is demultiplexed and converted back to the original set of VF signals and signalling. The terminal is full duplex, that is, each terminal contains both a transmit and receive capability.

The following sequence of operations are performed by the transmit section of the D2:

- VF and signalling conditioning
- time division multiplexing
- non-linear PCM encoding

- frame organizing
- bipolar conversion

The receive section of the D2 performs the inverse sequence of operations:

- unipolar conversion
- serial-to-parallel conversion
- frame synchronization
- non-linear PCM decoding
- demultiplexing
- VF and signalling conditioning

A discussion of the principles of time division multiplexing, non-linear PCM encoding and decoding, frame organization, synchronization used in the VICOM D2, and details of operation of the D2 follows.

A2-1.3 Time Division Multiplexing

Figure A2-1 schematically illustrates the process of time division multiplexing in the D2 channel bank. Each VF input signal is low pass filtered to 3450 Hz and fed to the sampling switch. The sampling switch sequentially rotates through the input channels and breaks them up into timed segments to form the Pulse Amplitude Modulated (PAM) sample train. This signal is the time division multiplex of the input channel. The receive side contains a distribution switch which is synchronized to the transmit sampling switch. The samples for each channel are separated and the original VF signals are reconstructed by the output low pass filters.

There are certain theoretical constraints on the above process. The original input VF signal must be band limited to less than one-half the sampling frequency. Samples must be short and uniformly spaced. The receive low pass filter must have a cut-off below one-half the sampling rate. These constraints are satisfied in the VICOM D2 equipment by making the cut-off frequency of both the input and output filters 3450 Hz and the sampling rate 8000 samples per second.

Figure A2-1 is a simplification of the actual case where 24 VF input channels are accommodated. Since each channel is sampled 8000 times per second the PAM sample train contains 8000 x 24 = 192,000 samples per second. Each individual sample is then only 5.2 microseconds in duration. The sampling and distribution switches are each representative of 24 individual analog gates controlled by a channel counter and channel select logic circuitry. In the transmitter, the channel counter is driven by

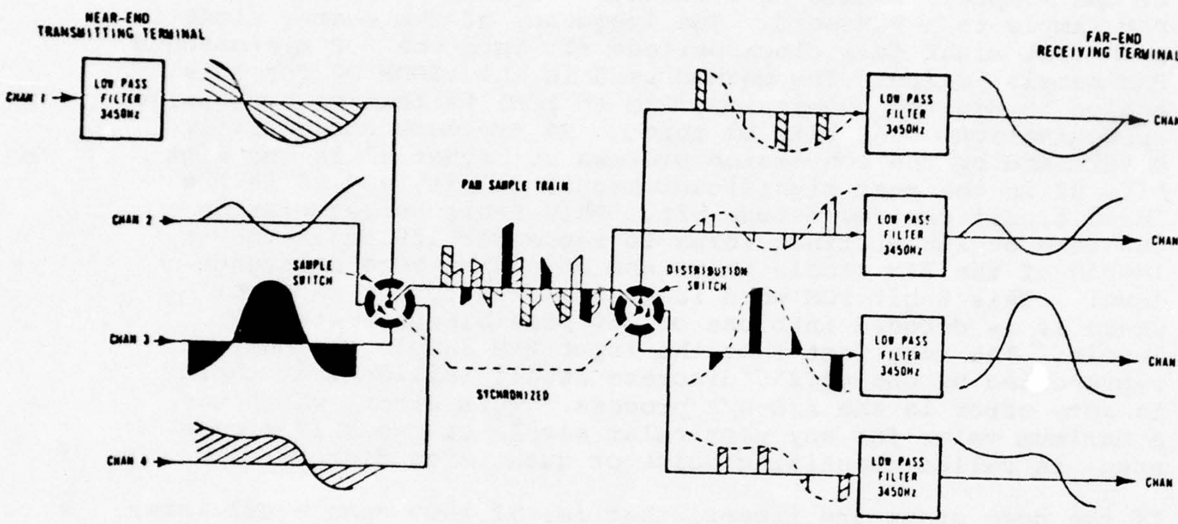


FIGURE A2-1. TIME DIVISION MULTIPLEXING

the master clock. In the receiver, master clock timing is extracted from the incoming bit stream by a phase lock loop. The receiver channel counter and select logic is synchronized to the transmitter by a framing pulse that is sent out by the transmitter and detected by the receiver.

A2-1.4 Non-Linear PCM Encoding

The D2 channel bank converts each PAM sample in the PAM sample train into an 8-bit Pulse Code Modulation (PCM) representation of the sample. Figure A2-2 illustrates the conversion of a PAM sample to a PCM word. The frequency of the master clock is such that eight full clock periods fit into the 5.2 microsecond PAM sample period. The method used in the VICOM D2 for this analog to digital conversion (PAM to PCM) is that of successive approximation. The bits B1 through B8 are each successively determined by the conversion process such that B1 is the sign bit, B2 is the most significant magnitude bit, and B8 is the least significant magnitude bit. This 8-bit representation can take on 256 distinct forms to represent 128 amplitude levels of the PAM sample above and below the zero reference level. This 8-bit PCM word is transmitted to the receiver where it is decoded into one of 256 possible discrete PAM levels. The very fact that the input PAM sample can only be represented by one of 256 discrete levels implies that there is some error in the A/D-D/A process. This error, which has a maximum value for any particular sample of one half a code step, is called quantizing noise or quantizing distortion.

If the code steps are linear, that is, if they span equal intervals of the input signal range, the quantizing error has a fixed peak-to-peak amplitude independent of the true signal amplitude. Thus, the signal-to-quantizing distortion ratio varies directly with the input signal strength, i.e., high for strong signals and low for weak signals. The consequence of linear encoding would then be good transmission for loud talkers, but poor transmission for soft talkers. This problem is reduced in the VICOM D2 channel bank by using non-linear encoding and decoding.

Figure A2-3 shows the non-linear encoding curve used by the D2 channel bank. Also shown on the figure is a linear encoding curve for comparison purposes. For a positive 0.5 volt input level the operating point on the linear curve is Q_L, which would be encoded into either the PCM word 00001111 or 00010000. For the same 0.5 volt input level the operating point on the non-linear curve is Q_N, which would be encoded either into the PCM word 01001111 or 01010000. This indecision as to what PCM

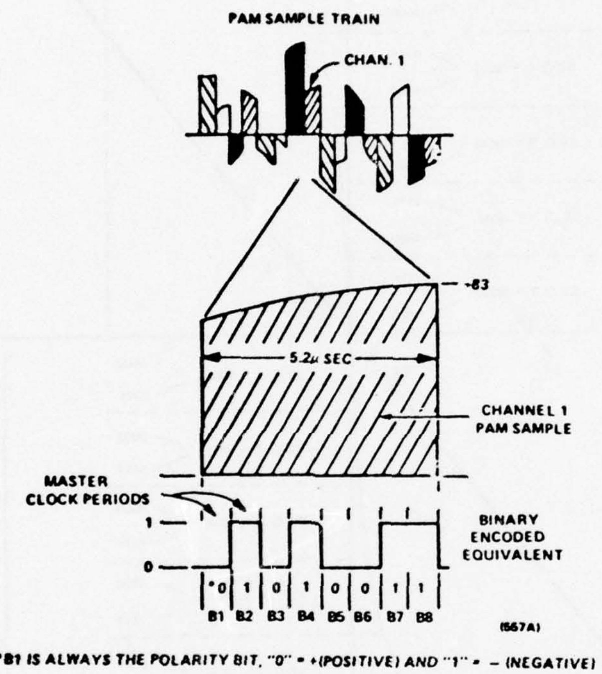


FIGURE A2-2. PAM TO PCM CONVERSION

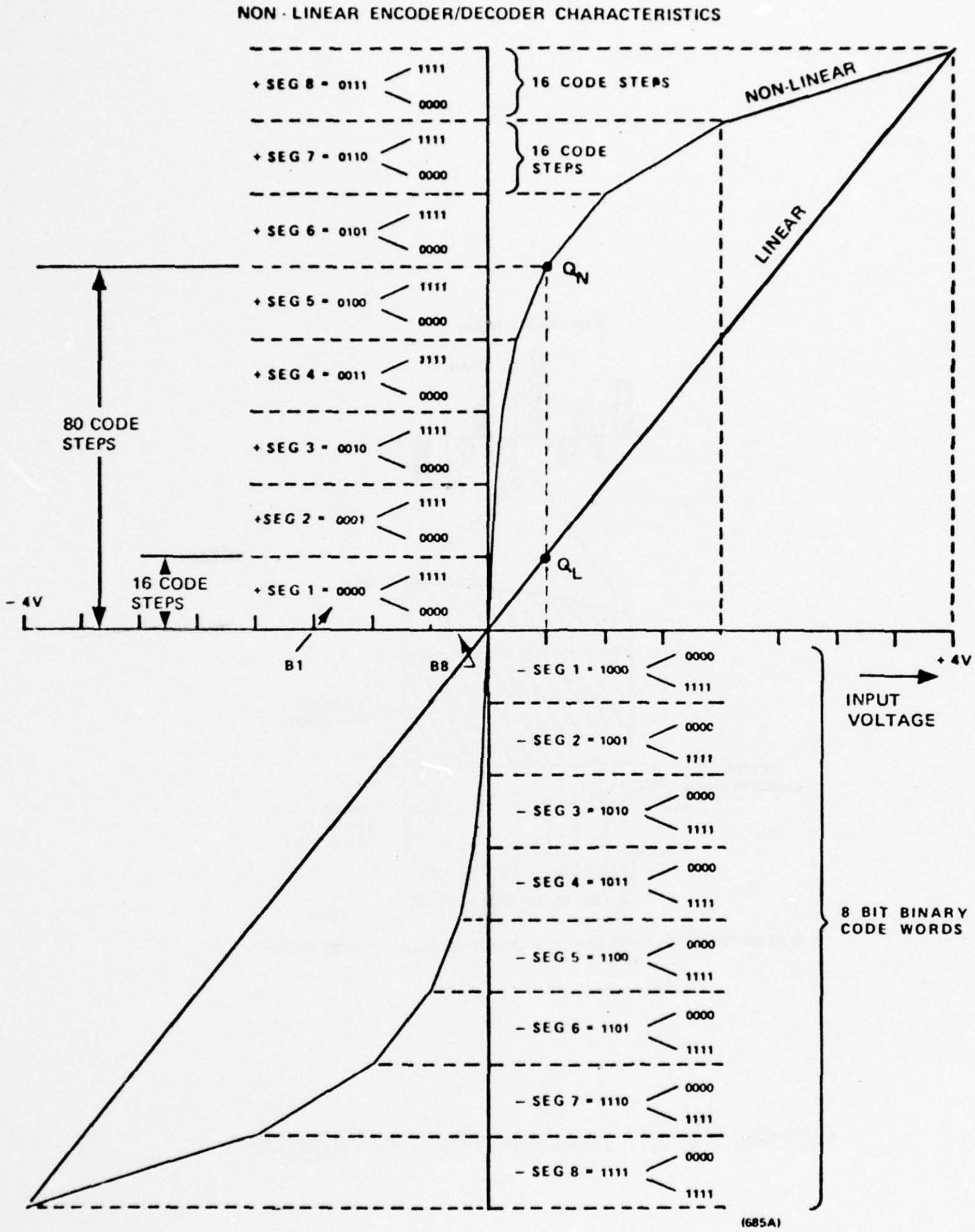


FIGURE A2-3. LINEAR VERSUS NON-LINEAR ENCODING

code to choose is at the heart of the problem. If the input voltage level were exactly at the threshold between the two PAM levels corresponding to these two PCM words, then a one-half code step error would result.

To illustrate the advantage of non-linear encoding over linear encoding, the relative quantizing distortion can be calculated. For Q_L the number of code steps spanned is 16. Thus, the maximum quantizing error is 3.125 percent (1/2 divided by 16). For Q_N the number of code steps spanned is 80 which results in a maximum quantizing error of 0.625 percent (1/2 divided by 80).

Note that the non-linear curve tends to expand weak input signals and compress strong input signals. This is commonly referred to as companding. In the VICOM D2 unit this operation is done on each PAM sample so that it is referred to as "instantaneous" companding as opposed to syllabic companding commonly used in VF telephone channels. The overall characteristic of the encoder-decoder together has to be linear if non-linear distortion is to be prevented. Thus, the characteristic curve for the decoder in the receive terminal must have a characteristic exactly inverse to that of the encoder.

A2-1.5 Frame Organization and Synchronization

Figure A2-4 depicts the frame organization of the VICOM D2. As described above, the transmit terminal samples all 24 input channels 8000 times per second. Each sample is encoded into an 8-bit PCM word and the 24 channel words are organized into a frame as shown in the figure. The organization of the channel words in this frame is compatible with the Western Electric equipment, that is, in the sequence 12, 13, 1, 17, 5, 21, 9, 15, 3, 19, 7, 23, 11, 14, 2, 18, 6, 22, 10, 16, 4, 20, 8, and 24. In order to maintain synchronization between the sampling switch in the transmitter and the distribution switch in the receiver, a framing bit is added at the start of each frame as a unique bit. Thus, a frame consists of 8 bits x 24 channels plus one framing bit, or 193 bits. Since the sampling rate is 8000 frames per second the overall bit rate is 8000 x 193 = 1.544 megabits per second.

It is also necessary to communicate channel signalling information between the VICOM terminals. The idle/busy status of each voice channel is transmitted by time sharing the least significant bit (B8) between voice and signalling. The B8 bits of each channel carry voice sample information for 5 frames followed by 1 frame during which they carry channel signalling information. This is followed by 5 more frames of B8 voice and another frame of B8 signalling. This sequence is repeated every 6 frames.

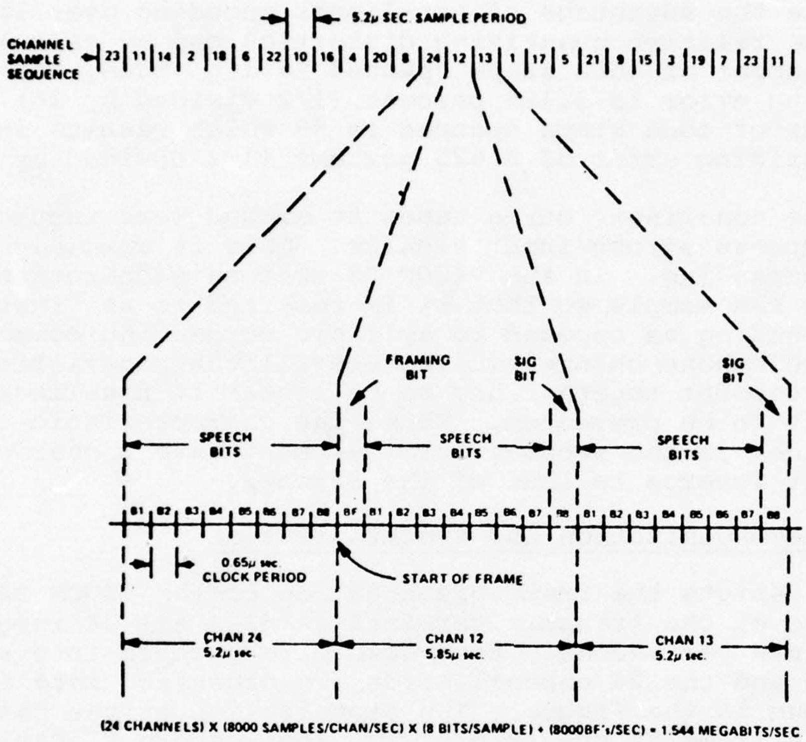


FIGURE A2-4. PCM FRAME FORMAT

A2-1.6 Transmitter Operation

With the above information as background it is now appropriate to discuss the way the VICOM D2 is implemented. Figure A2-5 shows a simplified block diagram of the transmitter. The circuitry related to signalling (idle/busy, etc.) is omitted from the diagram for clarity in describing the signal flow for voice signals.

The voice input and output signals interface to the D2 through a hybrid transformer which provides 30 dB of isolation between the transmit and receive signals. The input voice signal is then filtered by a 3450 Hz low pass filter before being sampled by means of the sampling switch and sample and hold. Note that the VICOM D2 breaks up the 24 voice channels into two groups, called here group A and group B. Group A consists of voice channels 1 through 12; group B consists of voice channels 13 through 24. The channel select logic sequentially cycles the two VF channel sampling switches which gates the VF input channels to the sample and hold circuits. The two switches are synchronized such that when the group A sample and hold is in the HOLD state, the group B sample and hold is not used. This allows time between samples for each sample and hold to stabilize at its PAM level prior to encoding the level into a PCM word by the non-linear PCM encoder. The two PAM streams are combined by the operation of the group select gate such that the PAM samples operated on by the PCM encoder are in the Western Electric compatible sequence. Since the PCM encoder is a successive approximation type D/A it outputs a serial stream in the order B1, B2, ---, B8 into the PCM word register.

When the PCM word register is full it is dumped in parallel into the code and signal combiner circuitry. This logic forms the 193 bit frame with the frame pulse BF between bit B8 of channel 24 and bit 1 of channel 12 as previously shown in Figure A2-4. It also inserts the signalling information for each channel in bit B8 of that channel word every sixth frame.

The output of the code and signal combiner is a serial NRZ binary stream which is operated on by the bipolar converter to yield the 1.544 Mb/s bipolar output stream.

A2-1.7 Receiver Operation

The simplified block diagram for the receive section of the VICOM D2 terminal is shown in Figure A2-6. The 1.544 Mb/s bipolar input stream is applied first to a unipolar converter which converts it to a binary NRZ stream. This serial stream

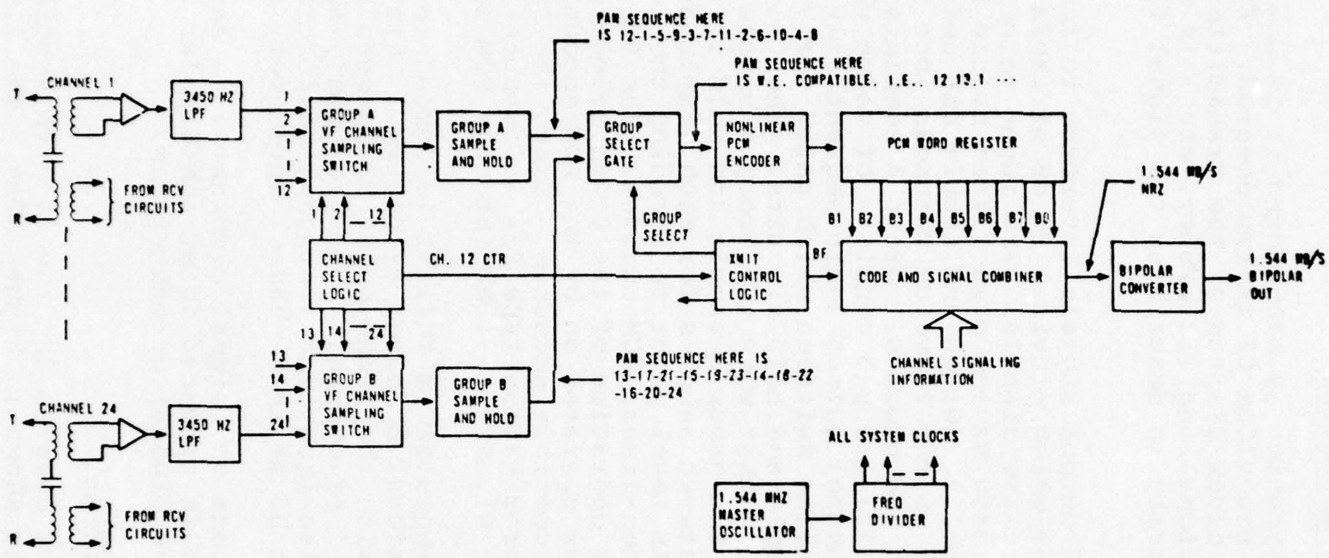


FIGURE A2-5. VICOM D2 TRANSMITTER BLOCK DIAGRAM

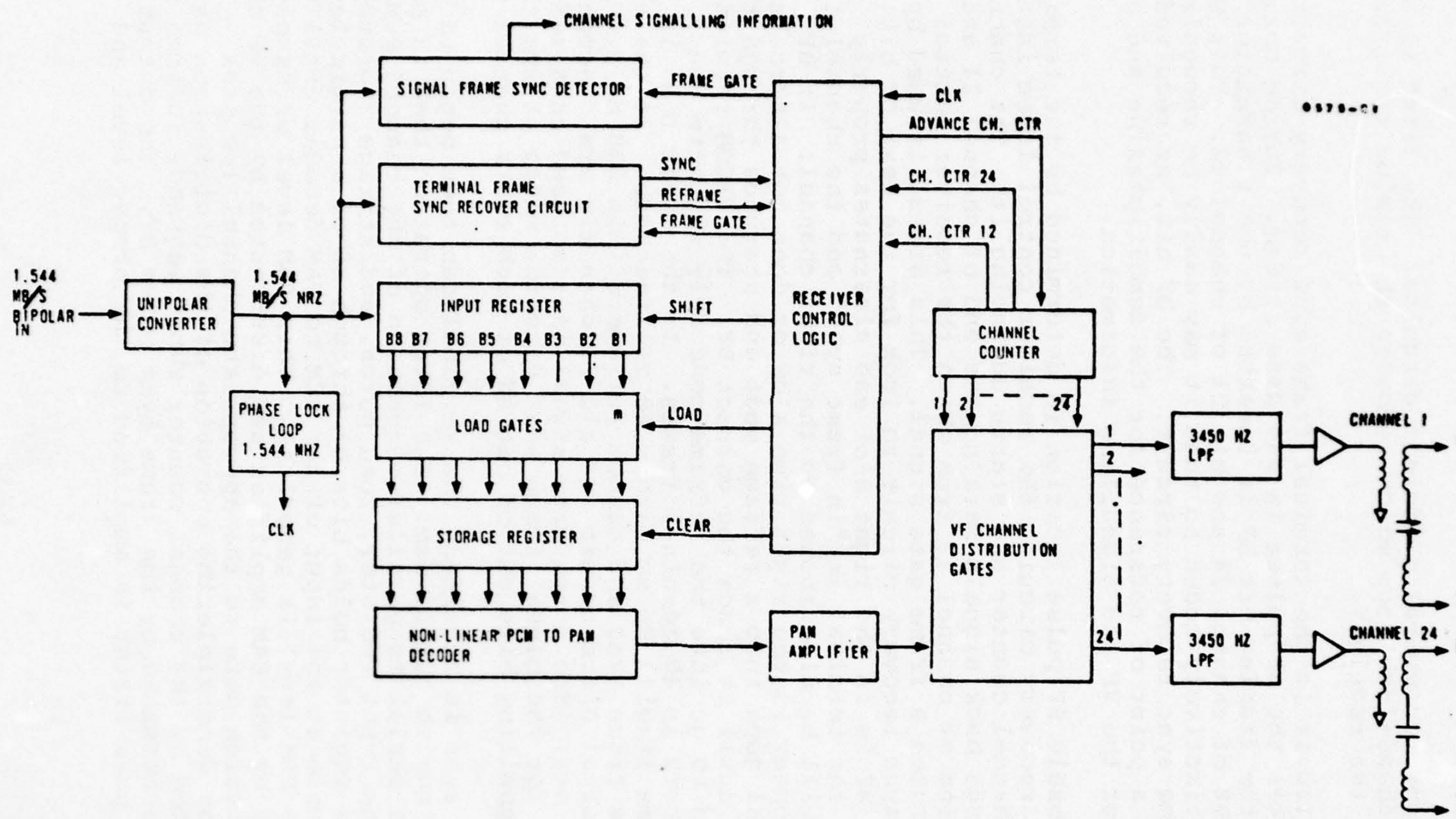


FIGURE A2-6. VICOM D2 RECEIVER BLOCK DIAGRAM

is then input to several different circuits. The first is a 1.544 MHz phase-lock loop which recovers the timing required to operate the receiver.

The next circuit is the terminal frame sync recovery circuit which locates the BF pulses in the data stream. During normal operation the framing bit BF is inserted by the transmitter between bit B8 of channel 24 and bit B1 of channel 12. This BF bit is distinctively coded so that it may easily be recognized by the frame sync recovery circuit. The BF bit, as received, is used as a point of reference for the demultiplexing and distribution of the VF and signalling information.

Once a probable BF pulse location is determined by the terminal frame sync recovery circuit, the receiver control logic initializes the channel counter and starts advancing it. The channel counter feeds back signals marking the end of channel 24 and the beginning of channel 12 from which the receiver control logic generates a frame gate signal. This signal is used by the frame sync recovery circuit to look for the next BF bit. As long as BF is in the right slot and alternates properly (1010---), the terminal is "in frame sync" and the channel information will be distributed to the right channel. If BF does not appear in the right time slow or does not alternate, the terminal goes into a reframe mode and searches through the bit stream until it finds the correct BF. The VICOM terminal is designed to go into the reframe mode only if there are 3 or more BF errors in 10 terminal frames. In the event that it must reframe it will do so within 40 milliseconds. If the terminal loses frame sync and cannot reframe within 800 milliseconds a Local Alarm occurs and all 24 channels are disconnected and busied out. The frame gate signal is also used as a reference point for the signal frame sync detector which strips the channel signalling bits out of bit B8 of each sixth channel word.

Once frame sync is acquired, the terminal can then begin to process the incoming bit stream. The first operation that is performed is a serial to parallel conversion of the channel PCM words by the input register, load gates, and storage register. The storage register holds bits B1 through B8 of a particular channel sample at the input of the PCM to PAM decoder until the appropriate PAM level is generated. This PAM level or sample is buffered by the PAM amplifier and distributed by the VF channel distribution gate to the appropriate channel low pass filter. The demultiplexing operation of the distribution gates is controlled by the channel counter whose sequence in time is of course determined by the frame sync pulse BF. The output of the low pass filter is amplified to the proper level and

coupled out of the VICOM D2 by means of the same hybrid transformer described in the transmitter discussion.

A2-1.8 Performance Assessment Considerations

The VICOM D2 receive terminal may lose frame temporarily due to bit errors caused by the transmission channel. As discussed above the receive terminal does not go into a reframe mode unless there are 3 or more BF comparison errors in 10 terminal frames (1930 bits). In the event that the terminal must reframe it will do so normally within 40 milliseconds. This reframing operation is done automatically by the terminal and is not an alarm condition. However, the reframe will cause a FRAME indicator on the front panel to illuminate.

If the receive terminal loses frame and cannot reframe within 0.8 second a Local Alarm occurs, a LOCAL front panel indicator illuminates, and a Service Alarm signal is generated. The Service Alarm initiates a Carrier Group Alarm (CGA) to disconnect and busy out all voice channels at the near end. It also provides the dry contact closures to operate office audible and visual alarms. The CGA may also be enabled by a blown fuse in which case a FUSE indicator is also illuminated on the front panel. The Local Alarm also causes an Outgoing Alarm (OGA) to be transmitted to the far end terminal. This is done by causing the transmitter to transmit all B2 bits as a logic 0, signalling the far end that the system is inoperative. When the far end terminal detects all B2's = 0 for 1.5 seconds the REMOTE indicator is illuminated and a Service Alarm is generated. As before the Service Alarm initiates a CGA and all the voice channels are disconnected and busied out.

It should be noted that the VICOM D2 unit can automatically recover from an alarm condition. Once the alarm condition is cleared the CGA circuits in the unit time through a sequence of events which causes both terminals to restore service simultaneously.

From the above discussion it can be seen that only one alarm is actually brought out of the VICOM D2 unit. That is the Carrier Group Alarm which may mean either a loss of frame sync or a blown fuse at either terminal. It should be noted here that this alarm is <u>not</u> brought out of the CY-104. The signal actually brought out of the CY-104 is the Service Alarm. Further the action of the Service Alarm to initiate CGA (which disconnects and busies out all voice channels) is inhibited in the CY-104.

There are several other signals available in the VICOM D2 which can be monitored for performance assessment providing they are made available. One is the number of BF MISCOMPARES (the D2 frame error) which is available at the output of a flip flop in the terminal frame sync recovery circuit of Figure A2-6. The other is the REFRAME signal which drives a front panel light and of course is derived from the BF MISCOMPARE signal. These are good indicators of overall end-to-end performance since, theoretically, D2 frame errors should be directly related to the T1 bit error rate because the probability of a frame bit being in error is equal to that of any other bit. Therefore, the T1 BER can be estimated and hence the quality of the overall PCM/TDM/MW transmission can be assessed.

The VF side of the D2 channel bank also holds some potential for performance assessment, not only for performance of the D2 itself, but also for end-to-end PCM/TDM/MW performance assessment.

In frequency division multiplex (FDM) systems, the quality of voice frequency (VF) channels is determined by a series of independent tests which include idle channel noise, phase jitter, harmonic distortion, intermodulation distortion, crosstalk, and impulse noise. These measurements under normal conditions can also determine the quality of a VF channel in a PCM/TDM system. Quantizing distortion, resulting from analog-to-digital conversion, is an additional measure of channel quality in a PCM/TDM system.

VF channel distortion measurements (phase jitter, harmonic distortion, intermodulation, quantizing distortion) are, with the exception of phase jitter, similar measuring techniques. Each requires a test tone to be inserted into the channel and each requires special test equipment. A common measuring technique was tested by AFCS which may provide a single qualitative measure (figure of merit) of signal distortion in a TDM VF channel. This technique uses a phase jitter meter and an RMS voltmeter to obtain a direct measure of phase jitter and an indirect approximate measure of signal-to-noise ratio. Signal-to-noise related readings are read directly from the voltmeter connected to the analog output of the phase jitter meter. AFCS made extensive measurements at varying test tone levels to compare this signal-to-noise (S/N) ratio with harmonic distortion and quantizing distortion.

The results were:

- Over the range of test tone (1020 Hz) levels from 0 dBm0 to -20 dBm0, the figure-of-merit and harmonic

distortion measurements bear an approximate linear relationship; with harmonic distortion approximately 15 dB down from the figure-of-merit readings.

- Quantizing distortion is 3 dB down from the figure-of-merit value of 0 dBm0; the difference however, increases to 16 dB at the test tone level of -40 dBm0.

- There is no significant relationship between the figure-of-merit values and idle channel noise readings.

An idle channel in the D2 channel bank may also be used more directly for performance assessment. For example, noise induced in the data stream will cause bit errors which appear as impulses in an idle PCM VF channel, rather than as an increase in idle channel noise. If the number and amplitude distribution of impulses in the VF channel can be accurately related to the T1 BER, an effective out-of-service quality check can be performed with an impulse noise counter. If T1 BER is further correlated with baseband signal degradation, a gross method of fault isolation can be developed. For example, if the impulse noise counter indicates a T1 BER which does not correspond to the baseband signal degradation, then it is reasonable to expect degradation in the receive terminal equipment after the baseband TDM input.

A2-2 CY-104 ALARM AND PARAMETER ANALYSIS DATA

CY-104 Alarms and Indicators fall into three categories:

Alarms Intended for External Use. These are alarms brought to a connector for external use. These all have an availability rating of 4.

Front Panel Alarms and Indicators. These currently light lamps visible from the front panel. Extraction may be feasible using light sensors on the front panel. Otherwise, considerable effort is probably involved to provide an electrical signal. These are assigned an availability of 2.

Internal Indicators. Because of the difficulty of extraction, recommendations are held to the most useful indicator.

Alarms Intended for External Use

1. Remote Alarm (HY-12)

Usefulness

PA/TA-2
During any interruption of service, the "service" alarms on the CY-104s on both ends of the duplex TDM channel will activate. The "remote" alarms may not actuate, however, depending on the sequence and speed of clearing. History and correlation with "service" alarm provides insight into the direction of transmission which is most troublesome.

FI-2
If detected, provides insight into the direction of transmission in which a fault originated.

Availability -4

Solder connection to lug at FL50.

Processing -4

None required.

2. Local (HY-12)

Usefulness

PA/TA-1
Nature of the system is such that a local alarm generates a local alarm at the far end, and a service alarm at both ends of the TDM link.

FI-2
If a determination can be made which of two conjugate CY-104s first went into local alarm, the source of a fault can be isolated to a direction of transmission.

Availability -2

Front panel lights.

Processing -2

Provides no more information than the service alarm without means to determine the sequence in which events occur at both ends of the link.

3. Service Alarm (HY-12)

Usefulness

PA/TA-3
Indicates a relatively severe interruption of user service. History and statistics of occurrence of this alarm provides a gross measure of quality of service.

FI-4
Obvious indicator of a fault.

Availability -4

Solder connection to lug at FL-49.

Processing -4

Existing ATEC software is intended to process this type of alarm.

Front Panel Alarms and Indicators

4. Frame (HY-12)

Usefulness

PA/TA-3
Although not very sensitive, this is the most sensitive indicator of high error conditions in the first two groups of availability. The rating reflects this compromise.

FI-1
Provides no insight into the conditions which created a framing error.

Availability -2

In addition to the generic problems of sensing front panel lights, this alarm latches, requiring actuation of a push button to reset.

Processing -2

Requires an event detector or event counter.

5. Carrier Group Alarm (HY-12)

Usefulness

PA/TA-1
Provides no information which is not provided by the service alarm.

FI-1
The comments under PA/TA apply.

Availability -2

Available at front panel lights.

Processing -4

Existing ATEC software is intended to process this type of alarm.

6. Loop Alarm (HY-12)

Usefulness

PA/TA-1
Not useful, per se. Indicates that the CY-104 is in the loopback mode. As such, is usable to indicate an abnormal condition which should not be used for PA/TA or FI. Other means may be available for performing this function.

FI-4
Provides a positive source of a fault, albeit due to human error.

Availability -2

Front panel light.

Processing -4

Existing ATEC software is intended to process this type of alarm.

7. Alarm Cutout (HY-12)

Usefulness

PA/TA-1
Not useful, per se. Indicates that the remote and service alarm connections to the outside would have been manually deactivated and, as such, may be of interest to the system.

FI-1
The comments under PA/TA also apply.

Availability -2

Front panel light.

Processing -4

Existing ATEC software is intended to process this type of alarm.

8. Fuse Alarm (HY-12)

Usefulness

PA/TA-1
No application to performance assessment. Because of its "two state" nature, it provides no measure of performance margin.

FI-2
Allows fault isolation within an equipment.

Availability -2

Front panel light.

Processing -4

Existing ATEC software is intended to process this type of alarm.

9. Restart (HN-74)

Usefulness

PA/TA-1
Indicates that CY-104 has ceased attempting to synchronize with its conjugate equipment. The same information is

conveyed by a service alarm which persists.

FI-4
Comments under PA/TA also apply.

Availability -2

Front panel light.

Processing -4

Existing ATEC software is intended to process this type of alarm.

10. Power On (HN-74)

Usefulness

PA/TA-1
No application to performance assessment. Because of its "two state" nature, it provides no measure of performance margin.

FI-1
Failure to apply primary power will be evidenced by other alarms.

Availability -2

Front panel light.

Processing -4

Existing ATEC software can process this type of alarm.

11. Fuse (HN-74)

Usefulness

PA/TA-1
No application to performance assessment. Because of its "two state" nature, it provides no measure of performance margin.

FI-2
Allows fault isolation within an equipment.

Availability -2

Front panel light.

Processing -4

Existing ATEC software is intended to process this type of alarm.

12. Power On (KG)

Usefulness

PA/TA-1
No application to performance assessment. Because of its "two state" nature, it provides no measure of performance margin.

FI-1
Failure to apply power will be evidenced in other ways.

Availability -2

Front panel light.

Processing -4

Existing ATEC software is intended to process this type of alarm.

13. Receiver Operate (KG)

Usefulness

PA/TA-1
Indicates apparent proper operation of KG. Since this, and more, information is conveyed by attainment of D2 synchronization, this indicator conveys information of marginal use.

FI-2
Insufficient detail is known about this indicator and its conjugate transmit indicator. They are possible fault isolation candidates when used in conjunction with each other.

Availability -2

Front panel light.

Processing -4

Existing ATEC software is intended to process this type of alarm.

14. Transmitter Alarm (KG)

Usefulness

PA/TA-1
This is not expected to exhibit transient behavior.

FI-2
Allows presumptive isolation of faults to this equipment.

Availability -2

Front panel light.

Processing -4

Existing ATEC software is intended to process this type of alarm.

15. Transmitter Operate (KG)

Usefulness

PA/TA-1
Indicates apparent proper operation of the KG. Since this, and more, information is conveyed by proper D2 operation, this indicator conveys marginal information.

FI-2
Insufficient detail is known about this indicator and its conjugate receive indicator. They are possible fault isolation candidates when used in conjunction with each other.

Availability -2

Front panel light.

Processing -4

Existing ATEC software is intended to process this type of alarm.

Internal Indicators

16. Frame Bit Miscompare

Usefulness

PA/TA-4
This is the single most sensitive indicator of error performance available without sending a probe signal through the system.

FI-4
Simultaneous comparison of frame bit errors with user side quality, and measurements along the data stream is a means of isolating error sources.

Availability -2

Requires internal modifications. Available at IC1B and IC1C on circuit board 7030-01.

Processing -2

An event counter is required, at a minimum.

Appendix A3

VICOM T1WB1 SUBMULTIPLEXER

A3-1 T1WB1 SUBMULTIPLEXER OPERATIONAL DESCRIPTION

The T1WB1 is a full duplex, time division multiplexer with a 1.544 megabit per second, bipolar pulse stream output (T1). The composite 1.544 Mb/s output consists of data bits from each of eight input channel plus framing bits which allow synchronization and recovery of the original channel data in proper order. The structure of the output data stream is shown in Figure A3-1. The output is organized into 193 bit frames; 192 bits contain channel information and one bit is the framing bit. The framing bit alternates between a "one" and a "zero" with each successive frame. The 192 data bits are further organized into twenty-four 8 bit sequences. In the normal T1WB1 configuration (eight 0-50 Kbs channels), one bit from each sequence is assigned to each channel.

Of the total 1.544 Mb/s output bit rate, 8000 bps are used for framing. The remainder, 1.536 Mb/s, yields 192 Kbs for each of the 8 channels. In the channel coding process, 3 output bits are used to encode each input bit, so that the maximum bit rate per input channel is 192 Kbs divided by 3, or 64 Kbs.

The channel encoding scheme used in the T1WB1 is shown in Figure A3-2 (Case a). Two clock phases, $\overline{\varnothing 1}$ and $\overline{\varnothing 2}$, are supplied to each channel unit. These clocks are at a rate of 192 Kbs. $\overline{\varnothing 1}$ is exactly 180° out of phase with $\overline{\varnothing 2}$. The encoded output line from the channel unit is normally at a logical "one" state. Whenever an input data transition occurs, several pulses coincident with the immediately following $\overline{\varnothing 1}$ clock pulses may occur in the encoded output stream. The first output pulse always occurs, and is called "Index". Its function is simply to indicate the occurrence of an input transition. The second is called "Quantize", and occurs if and only if the data transition occurred prior to the following $\overline{\varnothing 2}$ clock pulse (early). If the data transition occurred subsequent to the $\overline{\varnothing 2}$ pulse (late) the Quantize pulse does not occur (Case b). The third output pulse is called "State", and indicates whether the data transition was from a zero to a one. If the data transition was from a one to a zero the State pulse does not occur (Case b). Subsequent output bits are not used until another data transition occurs.

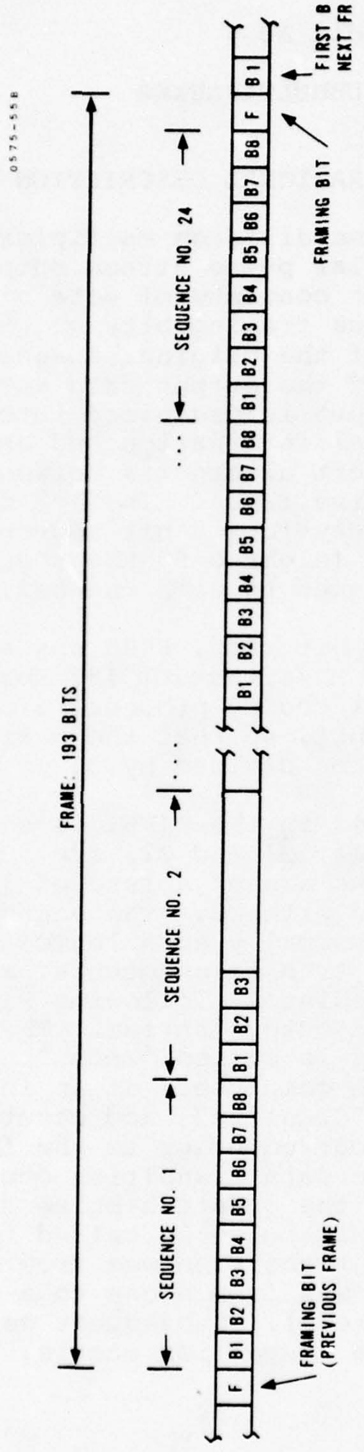


FIGURE A3-1. T1WB1 FRAMING FORMAT

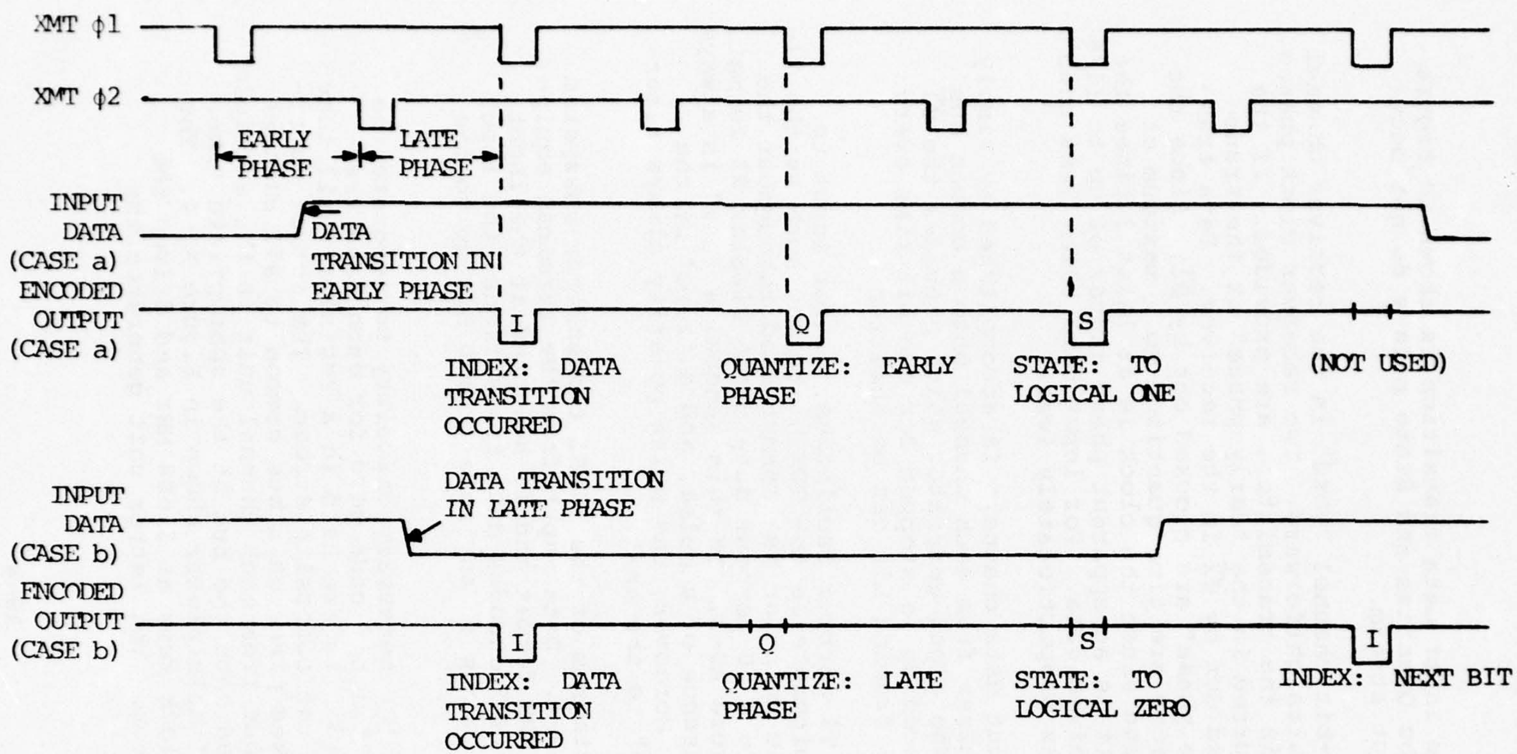


FIGURE A3-2. T1WB1 INPUT DATA ENCODING

An example of a late input data transition is shown in Figure A3-2b. Note that the Quantize and State pulses do not occur in the encoded output stream.

Decoding of the tri-bit channel "word" in the receiver channel unit is relatively straightforward. Two receiver clock phases, analagous to those in the transmitter, are provided. If the data transition occurred in the "early phase" at the transmitter, it is clocked out by $\overline{\text{Ø2}}$ in the receiver. Data transitions in the "late phase" are clocked out by $\overline{\text{Ø1}}$. Since the output data transitions are time quantized to a maximum of ±1/2 clock period, and since the clock is at least 3 times the data rate, the result is an apparent phase jitter of up to ±1/6 bit time in the received data. For input data rates less than 64 Kbs this jitter is proportionately less.

Multiplexing the input data channels is accomplished by simply gating the output pulses from each channel onto a common bus in time sequence. The clock generator which provides the $\overline{\text{Ø1}}$ and $\overline{\text{Ø2}}$ pulses for encoding is stopped for one bit time every 192 bits so that the framing bit can be inserted.

For transmission on T1 carrier facilities, or for input to other compatible equipments in the TDM hierarchy such as the T1-4000 multiplexer, the unipolar NRZ format used throughout the T1WB1 is converted to a 50 percent duty cycle bipolar RZ format. This is shown in Figure A3-3. In this scheme, a "one" is always indicated by the presence of a pulse, and a "zero" by the absence of a pulse. Moreover, the pulse polarity always alternates from each "one" to the next.

A simplified block diagram of the T1WB1 transmitter subsystem is shown in Figure A3-4. Data input from the terminal equipment is in unipolar NRZ format and is accepted at the input buffer. Since the T1WB1 encodes data transitions, the input is completely asynchronous at any rate from 0 b/s up to the maximum of 64 Kbs.

The encoder provides the necessary circuitry to generate the previously described tri-bit code word for each data transition. The code word bits are held in a register until they are multiplexed into the composite stream. The actual multiplexing operation takes place on a bus common to all channel units. The data output from each channel unit in the multiplex configuration is gated onto the bus at the appropriate time. This is the "phantom" multiplexer shown in Figure A3-4. The transmitter master clock runs at 3.088 MHz and drives the channel clock generator. The latter unit generates the

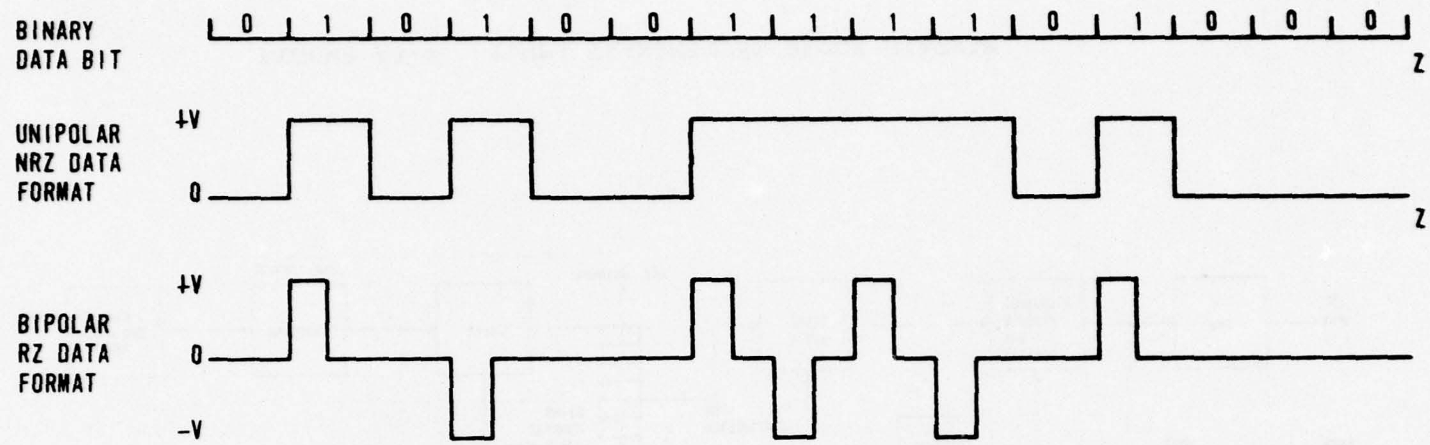


FIGURE A3-3. BIPOLAR RZ ENCODING EXAMPLE

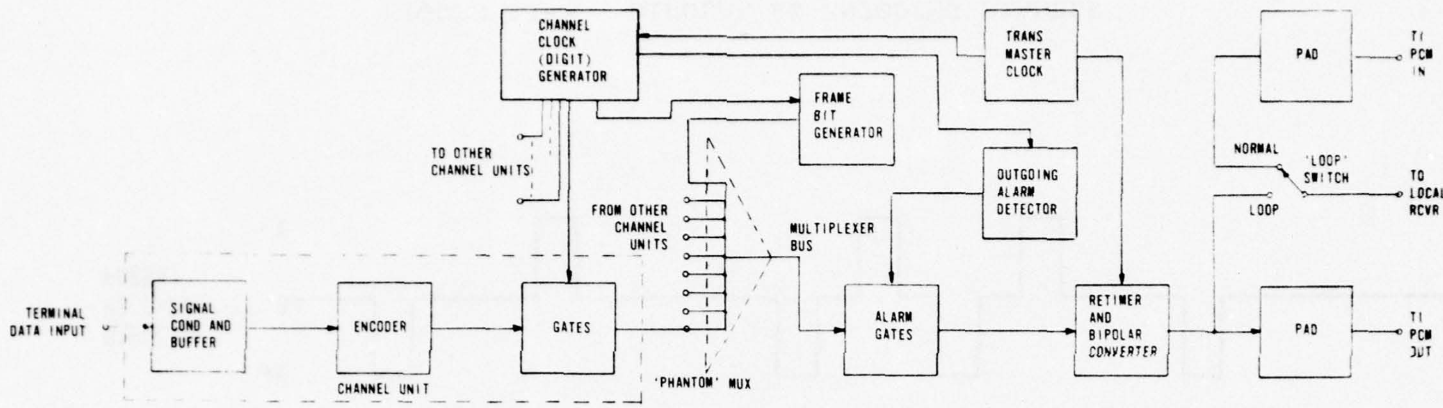


FIGURE A3-4. T1WB1 TRANSMITTER BLOCK DIAGRAM

transmitter $\overline{\emptyset 1}$ and $\overline{\emptyset 2}$ signals wiich are used to encode the input data and to gate the result onto the multiplexer bus at the appropriate time. The channel clock generator also suppresses the $\overline{\emptyset 1}$ and $\overline{\emptyset 2}$ output to the channel units every 192 bits so that the alternating frame bit can be gated into the composite multiplex.

The outgoing alarm detector responds to those conditions (discussed below) for which an alarm status is transmitted to the remote site, and causes all bits from channels 1 and 8 to go into the logical "zero" state. This is done by means of the alarm gate.

The retimer and bipolar converter transforms the internally used unipolar NRZ signal to a 50 percent duty cycle bipolar RZ T1 format for output. The T1 signal is passed through a 6 dB pad for level adjustment at the last point prior to output to the line.

The loop switch is used in certain fault isolation procedures, and in local terminal alignment. In the "loop" position, the transmitter output is fed back to the receiver intput so that the local terminal is looped back to itself through the T1WB1. A loop alarm indication is generated whenever the T1WB1 is placed in the loop mode.

A simplified block diagram of the T1WB1 receiver subsystem is shown in Figure A3-5. The T1 transmission signal is received at the input interface, which provides signal buffering. It is then routed through the loop switch which was discussed in the transmitter subsection.

The first step in processing the input signal is conversion from the bipolar RZ T1 format to unipolar NRZ. Since in the T1 format logical "ones" are always represented by the presence of a pulse on the line, logical "zeros" by the absence of a pulse, and the polarity always reverses from pulse to pulse, a means is available to perform limited error detection. If two consecutive pulses of the same polarity, either positive or negative, are ever received, a transmission error is indicated. This function is performed by the bipolar error detector.

The input signal is next passed through noise suppression circuitry which reclocks the input data using received data timing, thus eliminating the effect of some spurious transitions. The timing recovery circuit employs a phase lock loop to recover the 1.544 MHz clock from the data transitions. The retimed data is clocked into a buffer register. The

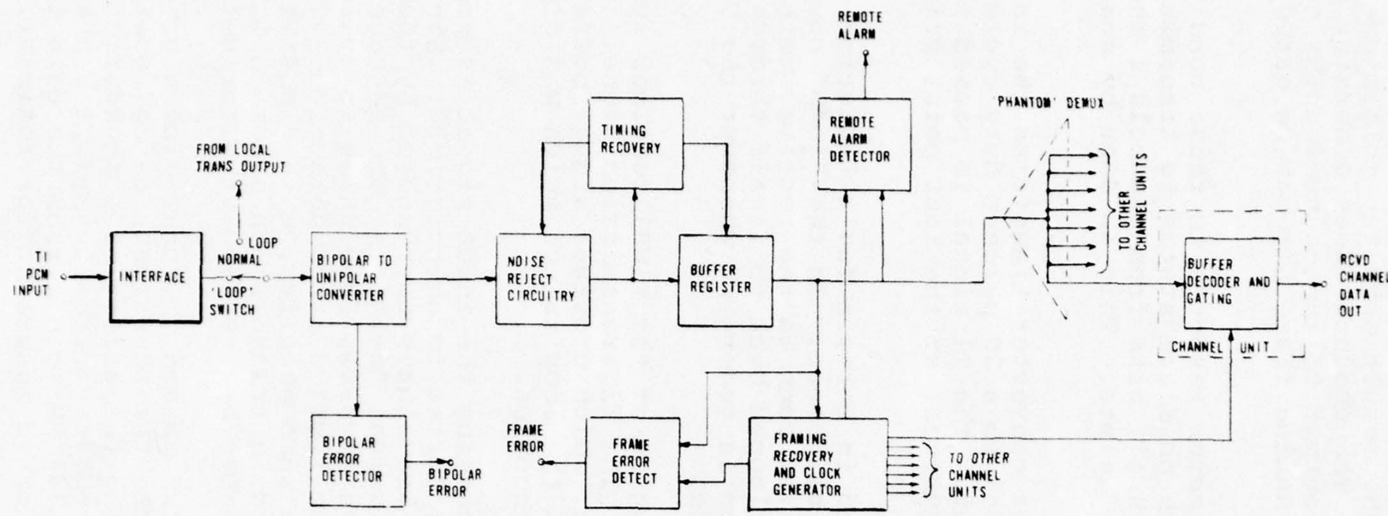


FIGURE A3-5. T1WB1 RECEIVER BLOCK DIAGRAM

framing recovery and clock generator searches the incoming data stream for the alternating framing bit (every 193rd bit). A confidence counter is used in the framing recovery subsystem to increase the "hardness" of the frame synchronization process. The system is not considered to be in the synchronized condition until 7 sequential correct framing bits have been received. Similarly, if the equipment is operating in the inframe condition, 3 framing errors in a 10 frame period are required to cause framing loss to be assumed. The frame error detector outputs an alarm under this condition and forces the equipment into the reframe mode. The clock generator outputs the set of receiver $\overline{\emptyset 1}$ and $\overline{\emptyset 2}$ signals used in the channel units to decode the received data signals.

The demultiplexing operation is analagous to the multiplexing operation in the transmitter in that the data bits are gated into each channel unit from a common bus. Each channel unit decodes its respective Index, Quantize, and State bits as described for multiplexing and encoding, but reversed 180° in phase, Figure A3-6 and buffers the resulting recovered channel data to the receiving terminal equipment.

The remote alarm detector monitores channels 1 and 8 for all zero condition, and, if detected, outputs an indication that an alarm condition exists at the remote transmitter.

The following alarm conditions which are detected in the T1WB1 are discussed in Volume I, Paragraph 3.3.

- Remote Alarm
- Frame Alarm
- Bipolar Error Alarm
- Loop Alarm

These alarms are indicated by the illumination of front panel lamps. Other alarm conditions, combinations, and results are discussed below.

A blown fuse in the -48 Vdc line will be detected and indicated by the Fuse Alarm.

A Frame Alarm which remains on for approximately 100 milliseconds (or longer), or a significant variation of the power supply voltages from their nominal value causes a Local Alarm signal to be generated and indicated.

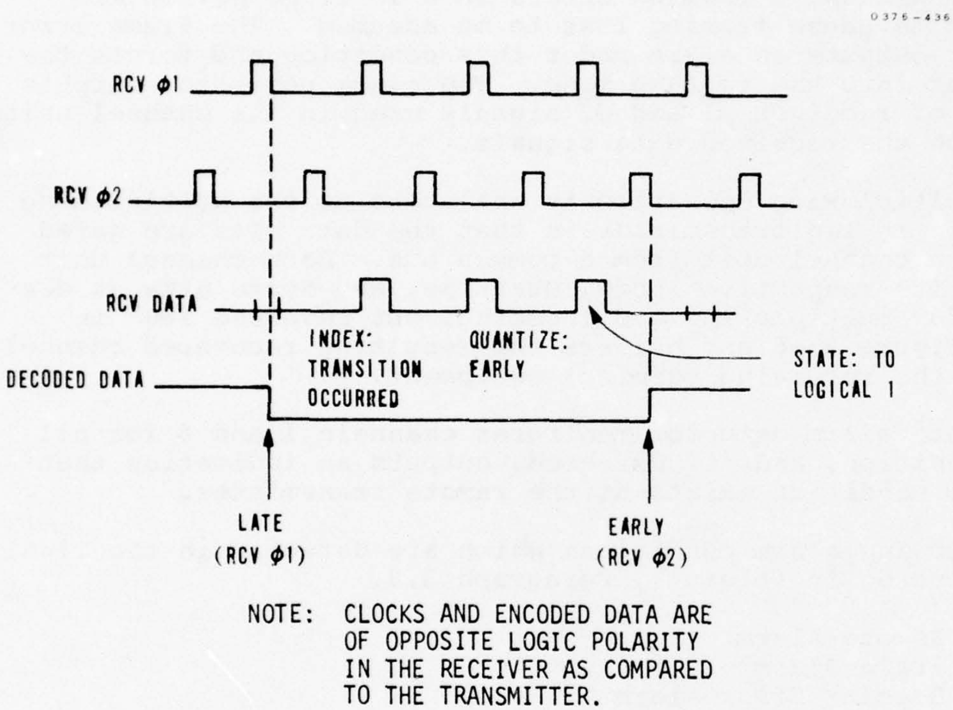


FIGURE A3-6. DATA DECODING

The occurrence of any of the above alarm conditions except Remote Alarm causes the Outgoing Alarm Detector to be activated and an alarm signal (all bits in channels 1 and 8 = logical zero) to be transmitted to the remote terminal.

The occurrence of any alarm, or loss of prime power, causes closure of the Office Alarm relay contacts. This signal is the only locally outputted alarm.

The T1WB1 alarm system is summarized in Table A3-1.

TABLE A3-1. T1WB1 ALARMS

Primary Alarm	Local Alarm	Alarm Action	
		Outgoing Alarm	Office Alarm Contact Closure
Frame Alarm	X	X	X
Bipolar Error Alarm	X	X	X
Remote Alarm	X		X
Loop Mode	X	X	X
Fuse Alarm		X	X
Power Supply Voltage	X	X	X
Prime Power Loss			X

A3-2 CANDIDATE MONITOR POINTS FOR THE T1WB1

Candidate Monitor Points for T1WB1 Receiver

1. T1 Received Bit Stream

   a. Electrical: The T1 output to the receiver is available as a balanced bipolar signal at the Power and Alarm Unit 5223 connector (J11), pins 19 and 20B.

      The signal is a 50 percent return to zero format with logic 1 represented by a pulse of the opposite voltage polarity of the last logic 1. Logic 0 is represented by no pulse. The pulse amplitude is ±3 volts. The

bit rate is 1.544 megabits per second.

This signal is available at the output of a 6 dB pad at the Receiver Unit 5222 connector (J10), pins 18B and 19B.

b. Since this is an equipment interface, the signal is potentially significant. It could be monitored for bit rate, jitter, amplitude or activity. The signal at the output of the 6 dB pad could be used to indicate the health of the pad, but has no other additional significance compared to the T1 output.

2. Recovered Clock

a. Electrical: A clock bit rate is extracted from the data with the use of a discrete transistor implementation of an astable multivibrator. This circuit is preceded by several one shots that are used to block noise spikes.

The $\overline{\text{RCV}}$ $\overline{\text{CLK}}$ signal is available at TP101 of the Receiver Unit SD5222; the test point is a TTL signal that is not isolated by a resistor. It is also available from a "differential" TTL line driver at the Receive Unit 5222 connector (J10), pins 20A and 20B. These two signals are TTL in nature, of opposite logic polarity. The signal at pin 20B is RCV CLK. The signals at 20A and 20B may not exist in the FKV equipment because they are a recent addition.

b. The received T1 signal will be generated in a local T1-4000 multiplexer, not at a remote site. Therefore, the T1 signal can be considered as an equipment interface rather than a signal that has been perturbated by a transmission channel.

Due to this, phase jitter and the like on the data or clock signal should reflect the T1-4000 output characteristics, not channel characteristics.

The clock recovery circuit is forced to phase coincidence with each falling edge of the data signal.

Between these resets, the clock is free running with no continuous feedback or flywheel effect. In this mode, the clock runs slow, slipping in phase with the data. Frequency of this signal or activity could be measured.

3. Bipolar Violations Error

a. Electrical: The received T1 signal represents logic 1 by a pulse. Successive pulses are to be of opposite voltage polarity. The VICOM receiver has a circuit that monitors for violation of this rule.

On the Receive Unit 5222, a TTL signal called ERROR is available at TP104 and connector pin 10A (J10). These two points are common electrically with TP104 having no isolation resistor. The signal at pin 10A is not used by the multiplexer.

It is a logic 1 pulse of one half bit time duration (324 nanoseconds) during the period when a bit is being received that violates the bipolar convention.

The ERROR signal is used to generate a 25 millisecond pulse called BP ERROR. This TTL signal remains a logic 1 when a violation is detected more often than once each 25 milliseconds.

BP ERROR is available at the Receive Unit 5222 connector (J10), pin 4A and at the Power and Alarm Unit 5223 connector (J11), pin 4A. The $\overline{\text{BP ERROR}}$ signal is available at J10-3A and J11-4B.

b. These signals indicate the health of the bipolar transmitter circuit, receiver circuit, and transmission channel. Since this is an equipment interface, with no interstation transmission, the error signals have limited system significance.

The ERROR signal could be counted to get an indicator of error rate. The BP ERROR signal is one possible source of an outgoing alarm. For this reason it could be monitored as an alarm to aid in fault isolation.

4. Frame Bit Errors

a. Electrical: Framing bit errors are detected in the Receive Unit 5222 and are indicated by a pulse on the FB ERROR signal. This TTL signal is available at TP1 on the Receive Unit, but is connected directly to the signal, having no isolation resistor. A detected error is indicated by a 324 nanosecond logic 1 pulse.

b. The rate of occurrence of this signal could be measured to estimate the bit error rate in the T1 channel and to detect high reframe rates.

5. Received Data After Clocking

a. Electrical: Clock data is available in the Receive Unit 5222 in TTL form at TP102 and connector pins J10-15A and J10-15B. The test point is connected directly to a flip-flop output with no isolation resistor.

b. Activity on this signal indicates proper operation of the recovered clock, receiver input buffer, and clocked flip-flop. Other indications are available, such as receiver frame synchronization. The clocked data could be monitored for activity or bit rate.

6. Channel Decode Clocks

a. Electrical: There are eight TTL clock signals, named D1-RCV through D8-RCV, that are generated in the Receive Unit 5222. Each receive channel unit receives two of the eight clocks which are used in decoding the received data. Each signal has an average rate of 192 kHz with each signal phased so that it is a logic 1 pulse when the others are logic 0.

The clocks are generated by decoding a divide by eight counter. The signals are available at the Receive Unit 5222 connector as indicated below:

D1-RCV	J10-2B	D5-RCV	J10-8B
D2-RCV	J10-3B	D6-RCV	J10-12B
D3-RCV	J10-6B	D7-RCV	J10-13B
D4-RCV	J10-7B	D8-RCV	J10-14B

b. These signals are the implementation of the demultiplex function. They cause each receiver channel unit to sample the receive bus at the appropriate time. It is possible for some of the signals to fail while others remain operational, therefore, monitoring all eight has some merit.

The framing bit block, DF, is generated by related circuitry. Monitoring this one signal for activity or frequency would give a good indication of the circuitry operation.

7. Framing Bit Clock

a. Electrical: The framing bit clock, DF, occurs once each frame during receipt of the framing bit. The $\overline{\text{DF}}$ signal is available at TP103, on the Receive Unit 5222, but is not isolated from the TTL signal. This signal is generated by the same circuitry that produces the channel decode clocks. Both the DF and channel decode clock signals will have jumps in phase during frame synchronization.

The GATED D6 signal also occurs once per frame. It is used in the generation of DF and has almost the same significance. This signal is not available at a connector, but is available at IC-24B-4 on the Receive Unit 5222.

b. The DF signal is more significant than GATED D6 and, therefore, is the primary candidate for monitoring.

The framing bit clock DF, is of primary significance to the receiver. It indicates operation of the derived clock, multiplexer clocks (D-RCV), and Receive Unit 5222 in general. This signal could be monitored for activity, frequency or jitter.

8. Received Output Data

a. Electrical: The output data is available at the individual Data Channel Unit 5234 connectors, pin 19. The connectors are J1 through J8. The signal is the standard MIL-STD-188C, low level, ±6 volts. The MIL-STD-188C signal is also available at TP101 on each channel unit. The test point is not isolated from the signal.

The output data is available in TTL form at TP3 which does not have an isolation resistor.

b. These signals are the ultimate output of the multiplexer system and, therefore, have great importance to the system user.

Activity, bit rate, jitter or amplitude could be measured. These signals will have considerable jitter due to the asynchronous multiplexing technique and phase jitter on the T1 signal. Jitter at this point may not have primary system significance since the

contribution made by the T1 channel can be measured at the T1 rate. However, due to the normally large amounts of jitter on the output signals, increases in jitter above the nominal may be a source of problems for the end user. Therefore, a measurement may be desirable.

9. Error Check (Redundancy)

   a. Electrical: The received state bit is available on the Data Channel Unit 5234 at IC-7A-2 when there is a rising edge at IC-7A-3. The inverse of the clock at IC-7A-3 is available at TP2. The test point does not have an isolation resistor.

      The clock signal at IC-7A-3 and TP2 is a very narrow, RUNT pulse. The signals that generate the clock may have to be used to regenerate the clock signal in the monitoring equipment.

   b. There is redundant information in the coding format that can be used to estimate the bit error rate of the channel from T1WB1 input to T1WB1 output.

      In particular, data transitions are encoded, but the new bit polarity is also transmitted. The new data bit logic polarity could be compared to the preceding received bit to determine if it did change state. When a change in state does not occur, one or more errors were made in transmission. These errors could be counted and averaged.

10. Bipolar Violation One Shot

   a. Electrical: The received T1 signal represents logic 1 by a pulse. Successive pulses are to be of opposite voltage polarity. The VICOM receiver has a circuit that monitors for violation of this rule.

      On the Receive Unit 5222, a TTL signal called ERROR is available at TP104 and connector pin 10A (J10). These two points are common electrically with TP104 having no isolation resistor. The signal at pin 10A is not used by the multiplexer.

      It is a logic 1 pulse of one half bit time duration (324 nanoseconds) during the period when a bit is being received that violates the bipolar convention.

The ERROR signal is used to generate a 25 millisecond pulse called BP ERROR. This TTL signal remains a logic 1 when a violation is detected more often then once each 25 milliseconds.

BP ERROR is available at the Receive Unit 5222 connector (J10), pin 4A and at the Power and Alarm Unit 5223 connector (J11), pin 4A. The $\overline{\text{BP ERROR}}$ signal is available at J10-3A and J11-4B.

b. These signals indicate the health of the bipolar transmitter circuit, receiver circuit, and transmission channel. Since this is an equipment interface, with no interstation transmission, the error signals have limited system significance.

The ERROR signal could be counted to get an indicator of error rate. The $\overline{\text{BP ERROR}}$ signal is one possible source of an out-going alarm. For this reason, it could be monitored as an alarm to aid in fault isolation.

11. Timing Phaselock Loop Control Voltage

a. Electrical: The signal that updates the internal free running clock to match the rate of incoming data is available at the collector of Q2, Receive Unit, 5222.

b. The internal free running clock has a nominal frequency below the expected bit rate. The rate is determined by resistor-capacitor (RC) circuits which afford some variability in frequency over temperature and time. The control signal, therefore, will normally exhibit control that will be variable over time independent of the input date rate. This will tend to conceal other anomalies.

Candidate Monitor Points for T1WB1 Transmitter

12. Transmitter Clock Source

a. Electrical: The transmitter clock is generated in a crystal controlled oscillator at a frequency of 3.088 megahertz. This signal is frequency divided by two in a flip flop before use in the transmitter.

The 1.544 megahertz basic clock is available on the Transmit Unit 5221 at TP104 and IC-1A-9. The test point is not isolated from the signal.

b. All transmitter timing functions are derived from this clock source and, therefore, is significant to performance. Monitoring the frequency or activity of the clock signal may be useful.

Monitoring of clock signals generated from the clock source could supply additional information at no added cost. If these signals are active at the proper frequency, it is highly likely that the basic clock source is also functional.

13. Channel Inputs

a. Electrical: SD5234 channel unit: The input signal is a MIL-STD-188C low level type. It is available at the channel unit connector (J1-J8), pins 2 and 3. Pin 2 is the active signal, pin 3 is ground.

b. SD5232 channel unit: The input signal may be either balanced polar non-return to zero or unbalanced unipolar non-return to zero format. The impedance level is 135 ohms; signal level is between 0 and -7 dBm.

14. Transmitter Bus

a. Electrical: The transmit bus from each of the channel units are common electrically. The signals are wire OR-ed using open collector logic gate outputs.

The $\overline{\text{XMT BUS}}$ signal is available at the Transmit Unit 5221 connector J9, pins 9A and 9B. The signal levels are basically TTL in format.

b. The common bus with proper timing is the implementation of the time division multiplex function. Activity of this signal is critical to equipment operation. It does not have other system level significance.

15. Channel Clocks (Transmit)

a. Electrical: Eight clocks with TTL levels are generated in the Transmit Unit 5221 for timing of the Transmit Channel Units. Each channel unit receives two of the clocks that are referred to as XMT 01 and XMT 02 at the channel unit.

Each of the eight clocks pulse at different times and control the phasing of the eight transmit channels multiplexing. Each clock has an average rate of 192 kHz, but changes phase by 1/8 period once each 24 clocks due to the insertion of the framing bit.

The signals are available at the Transmit Unit 5221 connector J9, as indicated below:

$\overline{D1}$ Pin 2B	$\overline{D5}$ Pin 8B
$\overline{D2}$ Pin 3B	$\overline{D6}$ Pin 12B
$\overline{D3}$ Pin 6B	$\overline{D7}$ Pin 13B
$\overline{D4}$ Pin 7B	$\overline{D8}$ Pin 14B

b. These signals are basic to multiplexer operation. The frequency, activity or relative phase could be measured.

The framing bit clock, $\overline{DF}$, is generated by the same circuitry as the channel clocks. Monitoring this one signal would give a good indication of proper clock operation.

16. Transmit Frame Bit Clock

a. Electrical: The framing bit clock, $\overline{DF}$, occurs at a rate of 8 kHz with a pulse width of 324 nanoseconds. It indicates the position of the framing bit in the transmit format.

b. The frequency of the framing bit clock, or activity, gives an indication of the health of the transmitter timing including the basic oscillator.

17. Frame Bit Generation

a. Electrical: The framing bit flip flop alternates state each frame. This signal is clocked into the $\overline{\text{XMT BUS}}$ by the framing bit clock $\overline{\text{DF}}$.

The framing bit flip flop signal is available at IC-7-11 on the Transmit Unit 5221. The signal is not available at the connector.

b. The frame bit is critical for proper demultiplexing at the receiver. The signals that drive the framing flip flop are also used in generating the framing bit clock, $\overline{\text{DF}}$. Monitoring one of these signals will supply almost as much information as monitoring both.

18. Transmitter T1 Output

a. Electrical: The T1 output signal is bipolar, return to zero, ±3 volt, 100 ohm, balanced.

It is available at the Transmit Unit 5221 connector J9, pins 18B and 19B.

The transmitted data is available inverted in TTL form at IC-6B-9 and TP101. The test point is not isolated from the signal.

b. As an equipment interface and ultimate output of the transmitter, this signal is significant from an equipment and systems viewpoint. The activity, level, or bit rate could be measured. Bipolar violation could be detected, however, this would only monitor the interface circuit since this is the transmit end.

Candidate Monitor Points for T1WB1 Power and Alarm Unit

19. DC Voltages

a. Electrical: The Power and Alarm Unit 5223 generates +5, +12, +15, +20, and -9 Vdc from a -48 Vdc power source. These signals are available as indicated below:

+ 5 Vdc	J11 and J12-11
+12 Vdc	J11 and J12-21
+15 Vdc	J11 and J12-22
+20 Vdc (unregulated)	J11 and J12-13
- 9 Vdc	J11 and J12-18

The +12 and +15 Vdc voltages are also available at TP3 and TP2 on the Power and Alarm Unit 5223. These test points are isolated from the supplies by 1K ohm resistors.

b. The primary power source and internal power supplies are critically important to operation. The voltage level of test signals can be measured.

The +10, -5, and -12 Vdc supplies are generated from other supply voltages. These could be excluded from monitoring due to their subordinate nature.

20. Reframe

a. Electrical: The criteria for loss of frame is three or more framing bit errors out of a group of ten.

When frame synchronization is lost and the multiplexer is attempting to reframe, the Receive Unit 5222 gives an indication at connector (J10), pin 14A, signal name FRAME. This signal is at approximately +0.7 volts during normal operation and -2 volts during an extend resynchronization. The FRAME signal also goes to -2 volts when the RCV CLK is inactive.

The signal is available in TTL form at IC-28B-6 in the Receive Unit 5222. A logic 1 indicates loss of synchronization or no clock activity.

The FRAME signal is also available at J11-14A, the Power and Alarm Unit 5223.

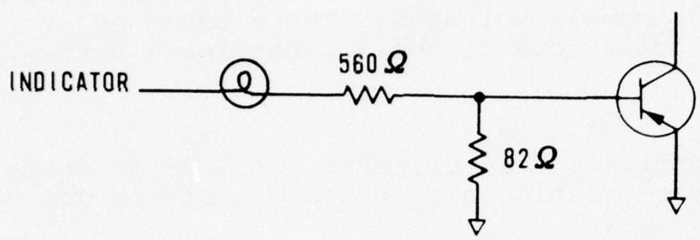
b. The FRAME signal is used in the Power and Alarm Unit 5223 to generate local alarm.

Frame synchronization is the major indicator of multiplexer health available directly from the equipment. The major sections of both the remote transmitter and local receiver must be operational to maintain frame synchronization.

The state of this signal could be monitored and the average rate calculated. This would give an indication of equipment health and channel error rate.

21. Fuse Alarm

a. Electrical: A blown fuse causes the -48 Vdc input power source to be connected to the INDICATOR signal. No alarm is indicated by ground through an inactive lamp in series with 560 ohms in series with the parallel combination of 68 ohms and the base to emitter junction of a PNP transistor, that is:



b. The -48 Vdc power source is fused with two series fuses. The output of the first fuse is used as a -48 Vdc source in the multiplexer. The output of the second fuse is used to power the dc to dc converter.

Opening of either fuse will give a fuse alarm.

The fuse alarm will cause an office alarm and outgoing alarm.

Monitoring the sources of these output alarms should be considered versus monitoring only the output alarms due to the additional information supplied.

22. Loop Alarm

a. Electrical: The present configuration of the loop switch is not easily monitored for state. If this signal is to be monitored, it is suggested that another pole be added to the loop switch.

The signal at the loop lamp could be monitored, but this is connected to the base of Q219 through low resistance in the Power and Alarm Unit 5223. This transistor is

the source of the outgoing alarm. Therefore, adding noise at this point through the monitoring circuitry could cause intermittent outgoing alarms.

b. When the receiver is looped to the local trans tter, the office alarm is disabled and an outgoing alarm is generated.

It is important to know the loop status of the equipment to properly assess the significance of other indicators in the system.

23. Remote Alarm

a. Electrical: Remote alarm can be sensed on the Power and Alarm Unit 5223 at the emitter of Q215. This signal is not available at a connector.

A remote alarm is indicated by a saturated transistor to ground. No alarm is indicated by -48 Vdc.

b. Remote alarm indicates receipt of a remote outgoing alarm. If the remote outgoing alarm is monitored, sensing the remote alarm itself has limited system significance.

24. Bipolar Violation Rate Alarm

a. Electrical: The bipolar violation error rate alarm can be monitored at the emitter of Q210 on the Power and Alarm Unit 5223. This signal is not available at the connector.

An alarm is indicated by a saturated transistor to ground. No alarm is indicated by +5 Vdc.

Care should be taken when monitoring this signal because it is connected to the base of a transistor through a 1K ohm resistor that can cause an outgoing alarm.

b. The bipolar violation error rate alarm is activated when the individual errors cause an RC circuit to charge to a threshold. In particular, a uniform error distribution with a rate of 2.6×10^{-5} will trigger the alarm within one-hundred milliseconds.

This alarm is not indicated directly on the Power and Alarm Unit, but does cause both an outgoing alarm and office alarm.

This alarm indicates the health of the T1 bipolar transmitter and receiver circuit, as well as, the transmission channel between them. Since the T1 signal is an equipment interface and not a communications channel in the FKV system, this alarm has limited significance.

25. Local Alarm

a. Electrical: Local alarm can be monitored on the Power and Alarm Unit 5223 at the collector of Q216. This signal is not available at the connector.

A local alarm is indicated by a saturated transistor to ground. No alarm is indicated by -48 Vdc.

b. Local alarm is initiated due to loss of receiver synchronization for more than five milliseconds or due to failure of the +5, +12 or -9 Vdc supplies.

A local alarm will cause an outgoing alarm and office alarm.

26. Outgoing Alarm

a. Electrical: The outgoing alarm is available at the Power and Alarm Unit connector J11-15A on TTL form. The high voltage level, logic 1, indicates an alarm.

The outgoing alarm can be overriden by a manual outgoing alarm cut off switch.

The outgoing alarm can be monitored at a point unaffected by the outgoing alarm cut off switch, the cathode of CR209 on the Power and Alarm Unit 5223. An alarm is indicated by -0.7 volts. No alarm is indicated by +5 Vdc or an open caused by a turn off transistor in parallel with a diode to ground. The +5 Vdc level will appear when the outgoing alarm cut off switch is not activated; an open will appear when the switch is activated.

b. An outgoing alarm is generated when any of the following conditions exist, and the outgoing alarm cut off switch is not activated:

Fuse Alarm

Bipolar Errors in Receiver

Local Alarm

Loop Alarm

An outgoing alarm is transmitted to the remote receiver. At the receiver, detection of the alarm is the remote alarm condition.

An outgoing alarm generates an office alarm. Therefore, monitoring only the office alarm would allow detection of an outgoing alarm, but a unique source of the alarm could not be determined directly.

27. Office Alarm

a. Electrical: The alarm is indicated by a closed relay contact. Two separate contacts are available at the Power and Alarm Unit 5223 connector, J11-6A to 6B and J11-7A to 7B.

A manual office alarm cut out switch is in series with the relay contacts for the purpose of overriding the office alarm indication.

The office alarm can be monitored at a point that is not affected by the office alarm cut out switch. This is at the collector of Q221. Alarm is indicated by -48 Vdc or no voltage caused by loss of power. No alarm is indicated by approximately -1.6 Vdc.

b. Office alarm is generated when any of the following conditions exist, and the office alarm cut out switch is not activated:

Remote Alarm

Local Alarm

Bipolar Errors in Receiver

Fuse Alarm

Loop Alarm

Outgoing Alarm Cut Off Switch

No Power

The office alarm is activated by all of the alarms provided by the multiplexer. Therefore, the office alarm, or the source of the alarm, is a prime candidate for monitoring.

A3-3 T1WB1 ALARM AND PARAMETER ANALYSIS DATA

A description and analysis of the candidate monitor points for the T1WB1 follows. Each candidate is analyzed and rated for usefulness, availability, and processing required. See paragraph A1-21 for a description of the rate values.

T1WB1 Receiver

1. T1 Received Bit Stream

   Usefulness

   PA/TA-1
   Unless the data sequence is known, by means of a probe signal for example, the knowledge of presence or absence of the data signal has no performance assessment significance.

   FI-3
   The knowledge of signal activity between pieces of equipment while not mandatory for fault isolation is extremely useful.

   Availability -3

   Available on connector pins J11-J19B and 20B.

   Processing -2

   A digital signal activity indicator would be required.

2. Recovered Clock

   Usefulness

   PA/TA-1
   If the recovered clock is not monitored for frequency deviation from the ideal by an accurate frequency counter, it does not impact performance assessment since knowledge of the presence or absence of clock does not contribute to performance measures.

FI-2
Presence or absence of recovered clock or even knowledge of the clock frequency does not impact fault isolation at the equipment level.

Availability -1

Available on board at SD5222; IC8E-8.

Processing -2

A digital signal activity detector or a frequency counter would be required to convert the signal into a form suitable for further processing.

3. Bipolar Violation Error

Usefulness

PA/TA-2, FI-2
Bipolar violation errors are not expected to occur due to the environment in which the equipment is employed. Specifically, the T1 signals are not transmitted over long cables. While they are not expected to occur, if errors did occur for some reason this fact would be somewhat useful, hence both variables are rated 2 rather than 1.

Availability -2

Available on connector pin J10-10A.

Processing -2

A counter would be required to count the violation prior to sampling by the monitor system.

4. Frame Bit Errors

Usefulness

PA/TA-4
The occurrence of frame bit errors provides a T1WB1 Tx to Rx error rate check and is the only means of determining the BER over this segment of the system without the use of a digital probe signal on one of the T1WB1 channels.

FI-4
Knowledge that the frame bit error rate is abnormal is important in fault isolation away from the T1WB1 receiver. For example, a continually reframing receiver coupled with a high frame bit error rate when frame synchronization has been achieved indicates a higher level multiplexer or radio link problem, not a T1WB1 fault.

Availability -1

Available on board at SD5222; IC27A-1.

Processing -1

A hardware counter and possibly special software which would exclude errors due to higher level system failures would be required.

5. Received Data After Clocking

Usefulness

PA/TA-1
Unless the data sequence is known, the received data is not of use in performance assessment.

FI-1
The received data provides little value in fault isolation. Knowledge of inactive output data while the input data is active could be employed to uncover a fault condition that may not otherwise be known.

Availability -2

Available on connector pin J10-15A.

Processing -2

A digital data activity indicator would be required.

6. Channel Decode Clocks

Usefulness

PA/TA-1
Knowledge of these internal equipment clock signals does not pertain to performance assessment. They are mainly significant to the internal functioning of the equipment and have only limited system level significance.

FI-2
Although this type of signal is very useful in fault isolation to the discrete component, it is not a comprehensive measure of the overall health of the equipment and, therefore, is not a cost effective monitor.

Availability -2

Available on connector pins J10-2B, J10-3B, J10-6B, J10-7B, J10-8B, J10-12B, J10-13B, and J10-14B.

Processing -2

A digital signal activity indicator would be required.

7. Framing Bit Clock

Usefulness

PA/TA-1
Internal clock signals are not useful for performance assessment. As in Item 6 they are mainly significant to the internal functioning of the equipment.

FI-3
This internal clock signal is rated 3 rather than 2 since it is of prime significance within the receiver. It indicates operation of the derived clock, multiplexer clocks, and receiver board number 5222 in general.

Availability -1

Available on board at SD5222; IC11D-11.

Processing -2

A digital signal activity indicator or a frequency counter would be required to monitor this clock.

8. Received Output Data

Usefulness

PA/TA-1
If the data sequence is not known, the data does not provide performance assessment information.

FI-3
Knowledge of active receiver output data contributes to the conclusion that the receiver is operational. Conversely inactive output data given active input data supports the position that a failure has occurred. Knowledge of data activity is not necessary, however, and the parameter is rated 3 and not rated 4.

Availability -2

Available on connector pins J1-19, J2-19, J3-19, J4-19, J5-19, J6-19, J7-19, and J8-19.

Processing -2

A digital data activity detector or indicator would be required.

9. Error Check (Redundancy)

Usefulness

PA/TA-4
This provides an end-to-end error check from the encoded data at the T1WB1 transmitter through the receiver output. However, this procedure is dependent upon input data activity in that if a channel does not have active data, the output may take a steady state form. In spite of this, the technique is postulated to be of significant importance in performance assessment.

FI-3
Due to its data dependence, this end-to-end estimation technique is rated 3 rather than 4 with respect to its usefulness for fault isolation.

Availability -1

Available in slots J1 through J8 on pin 19 and SD5234, IC8B-9 of each slot for channels 1 through 8. Also available in slots J1 through J8 on pins 19 and 20 and on SD5232; IC110-9 of each slot for channels 1 through 8.

Processing -1

Special hardware processing would be required. A value of 1 is assigned since the specialized hardware would not be useful for any other data processing task in the system.

10. Bipolar Violation One Shot

Usefulness

PA/TA-2
Bipolar violations normally occur due to channel disturbances which directly degrade the bipolar signal. However, errors are not expected to occur in this configuration of the equipment since the bipolar signal is used only within the station and not for long haul wire transmission. Therefore, this error is considered minimal in value.

FI-2
As violations should not occur, this parameter is rated 2.

Availability -2

Available on connector pin J11-4A.

Processing -2

Hardware processing in the form of an event counter would be required.

11. Timing Phaselock Loop Control Voltage

Usefulness

PA/TA-2
Knowledge of the recovered receiver timing has minimal value with regard to performance assessment because of the difficulty in calculating bit error rate as a function of timing error.

FI-1
This signal has minimal contribution to fault isolation for the same reason as stated above.

Availability -1

Available on board at SD5222; collector of Q2.

Processing -1

While hardware processing would be required, this parameter is assigned a value of 1 due to the complex hardware which would be of no value in other monitoring applications.

T1WB1 Transmitter

12. Transmit Clock Source

Usefulness

PA/TA-1
Of no value to performance assessment (refer to Item 6).

FI-2
Only of minimal usefulness in fault isolation at the equipment level (refer to Item 6).

Availability -1

Available on board at SD5221; IC1A-9.

Processing -2

A digital signal activity indicator would be required.

13. Channel Inputs

Usefulness

PA/TA-1
Of no value to performance assessment unless *probe signals* are employed for error rate monitoring.

FI-3
Useful for fault isolation in order to verify input signal activity and to correlate input signal activity with output signal activity.

Availability -1

Available on connector pins J1-2 and 3, J2-2 and 3, J3-2 and 3, J4-2 and 3, J5-2 and 3, J6-2 and 3, J7-2 and 3, and J8-2 and 3.

Processing -2

Hardware processing in the form of a digital signal activity indicator would be required.

14. Transmitter Bus

Usefulness

PA/TA-1
Of no value in performance assessment for the same reasons as cited in Item 6.

FI-2
Knowledge of the signal activity on the common transmitter output bus is of minimal value in equipment level fault isolation. This signal can be more readily monitored at the receive end of the transmission path since the quality of this signal is difficult to measure without a receiver.

Availability -2

Available on connector pin J9-9A.

Processing -2

Hardware processing in the form of a digital data activity indicator would be required.

15. Channel Clocks (Transmit)

Usefulness

PA/TA-1
Of no value in performance assessment (refer to Item 6).

FI-2
Knowledge of the individual channel clock is only of minimal value in system level fault isolation (as above).

Availability -2

Available on connector pins J9-2B, J9-3B, J9-6B, J9-7B, J9-8B, J9-12B, J9-13B, and J9-14B.

Processing -2

Special hardware processing in the form of digital signal activity indicators would be required.

16. Transmit Frame Bit Clock

Usefulness

PA/TA-1
Of no value in performance assessment (refer to Item 6).

FI-3
This signal constitutes one of the few internal monitor points which may be used to provide a general indication of proper transmitter operation. While not extremely useful (4) since it provides only a presumptive indication as to the general health of the clock system it certainly warrants a rating of 3.

Availability -1

Available on board at SD5221; IC16A-12.

Processing -2

Hardware processing in the form of a digital signal activity indicator or frequency counter would be required.

17. Frame Bit Generation

Usefulness

PA/TA-1
This is an internal timing signal and is not of value with respect to performance assessment (refer to Item 6).

FI-2
An internal timing signal is of marginal value in system level fault isolation (as above).

Availability -1

Available on board at SD5221; IC7-11.

Processing -2

A digital signal activity indicator would be required.

18. Transmitter T1 Output

Usefulness

PA/TA-1
Knowledge of the composite output data activity is not of value in performance assessment. The quality of this signal would be very difficult to determine without the use of a receiver.

FI-3
Knowledge of transmitter output signal activity is important to fault isolate between failures in the T1WB1 and higher level multiplexers. Since only a data signal activity monitor is postulated, a rating of 4 is not warranted.

Availability -3

Available on connector pins J9-18B and J9-19B.

Processing -2

Processing in the form of a data activity indicator would be required.

T1WB1 Power and Alarm Unit

19. DC Voltages

Usefulness

PA/TA-3
Power supply voltages are useful to monitor gradual supply degradations in order to permit maintenance prior to supply failure. Voltage deviation from nominal and the rate of change of the deviation are both important contributors to performance margin.

FI-4
Since a major source of equipment failure arises due to power supply failures, knowledge of the general state of the output power supply voltages is extremely important with respect to fault isolation.

Availability -3

Available on connector pins:

DC voltages are available at to connector level as follows:

J11 and J12-11	+ 5 Vdc
J11 and J12-21	+12 Vdc
J11 and J12-22	+15 Vdc
J11 and J12-13	+20 Vdc
J11 and J12-18	- 9 Vdc

Processing -3

If voltages are measured by an MTU for example, only software processing would be required. It is postulated that a simple comparator type circuit could output a "state" or binary signal to the ATEC equipment in lieu of an MTR.

20. Reframe

Usefulness

PA/TA-4, FI-4
The condition of frame synchronization is an important indicator that the remote multiplexer transmitter and the local receiver are operating properly. Moreover, it is directly related to performance of the system at the user level. The relative number of reframes is useful in the computation of system availability and knowledge of the frame condition is necessary for effective fault isolation.

Availability -1

Available on board at SD5222; IC28B-6.

Processing -3

Assuming the monitor system scan rate is adequate, only software processing would be required. If the scan rate is too slow a resettable latch or a counter would be required to interface this signal with the monitor system.

21. Fuse Alarm

Usefulness

PA/TA-1
Not relevant to performance assessment. Because of its "two state" nature, it provides no measure of performance margin.

FI-4
Very important for rapid fault isolation at the system level. This alarm indicates loss of service of the entire equipment.

Availability -1

Available on board at SD5223; DS105.

Processing -4

A circuit would be required to monitor the state of the lamp driver, however, no further special processing is required.

22. Loop Alarms

Usefulness

PA/TA-1
Alarm parameter indicating a looped condition of multiplexer is irrelevant to performance assessment.

FI-4
Knowledge that a multiplexer is in a loop back configuration is essential to system fault isolation to the equipment level. It is postulated that a looped condition may only be detectable by a loop alarm (excluding the use of probe signals).

Availability -1

Available on board at SD5223; DS106.

Processing -4

As this is a binary or "state" alarm, no special processing is necessary.

23. Remote Alarm

Usefulness

PA/TA-2
This alarm is only of negligible value for performance assessment. Because of its "two state" nature, it has minimal information content and, therefore, is not practical as a measure of performance margin or degree of degradation. Additionally, the same information is more readily available at the source of the fault.

FI-2
This alarm is of negligible value for fault isolation since the send alarm conveys the same information and is electrically closer to the fault location.

Availability -1

Available on board at SD5223; emitter of Q215.

Processing -4

No special hardware or software processing would be required.

24. Bipolar Violation (Rate Alarm)

Usefulness

PA/TA-2, FI-2
Bipolar violation errors are not expected to occur due to the environment in which the equipment is employed. Specifically, the T1 signals are not transmitted over long cables. While they are not expected to occur, if errors did occur for some reason this fact would be somewhat useful, hence both variables are rated 2 rather than 1.

Availability -1

Available on board at SD5223; emitter of Q210.

Processing -2

Hardware processing in the form of a counter would be required.

25. Local Alarm

Usefulness

PA/TA-2
This alarm is of marginal utility. It occurs due to loss of receiver synchronization or one of the power supplies. The reframe content of this alarm is highly useful, but redundant, since this information is directly available as REFRAME without the complicating interference of the power supply monitor.

FI-2
Marginally useful. OFFICE ALARM gives a more comprehensive indication of hard failure and occurs whenever LOCAL ALARM is activated.

Availability -1

Available on board at SD5223; collector of Q216.

Processing -4

No special processing would be required due to nature of alarm.

26. Outgoing Alarm

Usefulness

PA/TA-2, FI-2
Of marginal utility for both performance assessment and fault isolation since this alarm is simply a combination of fuse alarm, bipolar violation alarm, local alarm, and loop alarm. Primarily this alarm can be manually overridden which would defeat the purpose of the monitor system. Secondly, the OFFICE ALARM is also activated by these signals and is more comprehensive.

Availability -1

Available on board at SD5223; cathode of CR209.

Processing -3

Due to nature of alarm, no special processing would be required.

27. Office Alarm

Usefulness

PA/TA-2
Being a combination of numerous alarms, this alarm is of marginal performance assessment usefulness. It requires that fault isolation be performed to identify the anomaly prior to evaluation for performance assessment.

FI-4
This alarm is a combination of the following alarms and conditions and is extremely important for fault isolation, remote alarm, local alarm, bipolar violation alarm, fuse alarm, loop alarm, outgoing alarm cut off switch, and no power.

Availability -4

Available on connector pins J11-6A and J11-6B.

Processing -4

No special processing required.

Appendix A4

VICOM T1-4000 EIGHT PORT TDM

A4-1 T1-4000 OPERATIONAL DESCRIPTION

A4-1.1 Introduction

The T1-4000 is an asynchronous, time division multiplexer capable of multiplexing up to eight channels of 1.544 megabit per second (Mb/s) (T1) bit streams into a single 12.5526 megabit per second bit stream. In the FKV, the source of the individual T1-4000 channels are T1WB1 and CY-104 multiplexers.

The output of the T1-4000 transmitter is a three level partial response signal that is used as the baseband for the line of sight radio. The partial response format is implemented by frequency domain filtering, with half of the filtering done in the transmitter output and the other half in the receiver input.

The multiplexer is asynchronous in that the channel input bit streams may have any phase and a limited variation in bit rate. The T1-4000 is designed to accommodate variations in bit rate of +150 to -300 bits per second from nominal.

The specifications for the multiplexer as presented by VICOM are listed in Table A4-1.

Various models are available to accommodate different numbers of channels. Output bit rate versus the number of channels is shown below.

Number of Channels	Bit Rate (Mb/s)
2	3.1864
4	6.2763
6	9.4631
8	12.5526

Only the eight channel model is used in the FKV.

The T1 signals are bipolar, 50 percent duty cycle, ±3 volt peak pulse streams. Figure A4-1 presents an example of T1-50

TABLE A4-1. FIRST LEVEL MULTIPLEXER EQUIPMENT SPECIFICATIONS

Electrical

Input Bit Rate and Format:	1.544 Mb/s (+150, -300 bits); ±3 ±0.3V bipolar, 50 percent duty cycle
Error Rate:	$\leq 3 \times 10^{-7}$ for satisfactory operation
Maximum distance between T1 equipment and multiplexer:	150 feet
Stuffing Jitter:	Allows standard T1 terminals to operate over a minimum of 8 tandem multiplexer hops
Multiplexed Signal Format:	Three-level partial response (half filtered before and after transmission). Format may also be two-level via strapping options
Output Level (Transmit Side):	Selectable between 1.0 ±0.1V p-p and 0.3 ±0.3V p-p
Impedance:	75 ohms (±5 percent), unbalanced for transmit and receive sides
Input Level (Receive Side):	0.05 to 1.5V p-p
Signal-to-Noise Ratio:	23 dB peak signal-to-rms noise ratio produces 3×10^{-7} error rate (maximum) for received signal between 0.5 and 1.5V p-p
Signal-to-Noise Ratio Degradation:	$\leq$ 1 dB at following maximum cable lengths: 300 feet (2-port and 4-port versions); 200 feet (6-port version); 150 feet (8-port version)

TABLE A4-1. FIRST LEVEL MULTIPLEXER EQUIPMENT SPECIFICATIONS (CONTINUED)

Electrical (Continued)

Bit Rates:	3.1864 Mb/s (2-port version); 6.2763 Mb/s (4-port version); 9.4631 Mb/s (6-port version); 12.5526 Mb/s (8-port version); ±0.005 percent tolerance for each version
Transmission Bandwidth:	Approximately 800 kHz (±3 dB) per T1 port
Transmit Clock:	Square wave, 50 percent ±20 percent duty cycle, 1.0 ±0.1V p-p output into 75 ohms
Synchronization Clock:	0.5 to 1.5V p-p input across 75 ohms, square wave or sine wave
Remote Alarm:	Indicates outgoing circuit failure (near-end XMT or far-end RCV); detected at far-end and transmitted to near-end
Local Alarm:	Indicates incoming circuit failure (near-end RCV or far-end XMT); detected at the near-end
Major Alarm:	Relay closure to office alarm system indicates system failure (remote or local) or manual shutdown (system looped)
Minor Alarm:	Relay closure to office alarm system indicates performance deterioration or high error rate ($> 10^{-5}$)

TABLE A4-1. FIRST LEVEL MULTIPLEXER EQUIPMENT SPECIFICATIONS (CONTINUED)

Electrical (Continued)	
T1 Terminal Alarm:	Local alarm or looped condition at the multiplexer transmits constant pulse stream (full density) on all T1 channels serviced by the multiplexer, causing D2 banks to go into alarm. Also, alarm code is sent to far-end multiplexer where remote alarm lamp is lit and major alarm relay is operated
Power Requirements:	115 ±10V ac (60 Hz), -50 ±6V dc, or -25 ±3V dc; 120 watts maximum
Fusing:	1.6 amps (slow-blow) at 110-115V ac; 2 amps (fast-blow) at -48V dc; 5 amps (fast-blow) at -24V dc
Power Dissipation:	60 watts (common equipment), pulse 6 watts per T1 port (two channel units)
Mechanical	
Multiplexer Shelf Dimensions:	Designed to mount on 19-inch rack. Each shelf measures 18-1/2 inches wide by 12 inches deep. Shelf height is as follows: 10-1/2 inches (2-port and 4-port shelves); 15-3/4 inches (6-port and 8-port shelf)
Equipment Module Dimensions:	Each plug-in unit measures 10-3/8 inches long x 4-1/2 inches high
Shelf Weight (Fully Equipped):	18 pounds (2-port); 32 pounds (4-port); 42 pounds (6-port); 46 pounds (8-port)

TABLE A4-1. FIRST LEVEL MULTIPLEXER EQUIPMENT SPECIFICATIONS (CONTINUED)

Environmental

Temperature:	$+30^{\circ}F$ to $+120^{\circ}F$ ($+1^{\circ}C$ to $+49^{\circ}C$)
Humidity:	Up to 90 percent relative humidity at $100^{\circ}F$ ($38^{\circ}C$)

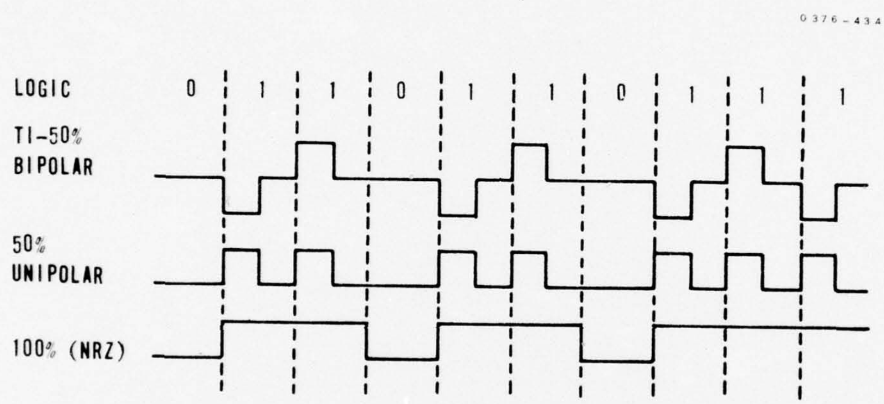


FIGURE A4-1. T1 AND NRZ WAVEFORMS

percent bipolar, 50 percent unipolar, and 100 percent non-return to zero (NRZ) formats.

Logic 1 levels are represented by a pulse; logic 0 levels are represented by the lack of a pulse. Each pulse is of opposite voltage polarity but except for this, the polarity contains no information.

A4-1.2 Equipment Operation

A simplified block diagram of the T1-4000 multiplexer is shown in Figure A4-2.

On the transmit side, the multiplexer accepts input data in the standard T1 1.544 Mb/s bipolar RZ format. Up to 8 channels are accepted, each through a separate plug in the PCM access module. The input data is first converted into unipolar NRZ format. Transmit timing is recovered from each individual data stream.

Since the input data streams are asynchronous (they may vary as much as plus or minus 75 b/s from the nominal 1.544 Mb/s rate) provision must be made to "equalize" them prior to combination. This is done by means of a technique called "stuffing". The data is clocked into a serial buffer register at the near-nominal rate. Data is clocked out of this register at a slightly higher rate, 1.544935 Mb/s. Of this output, 1.542253 Mb/s are always T1 data bits, and the difference (2682 b/s) may or may not be T1 data. Bits are added in the 2682 b/s substream whenever needed to maintain the composite buffer output at exactly 1.544935 Mb/s. When a bit is added and contains no information, it is referred to as a "stuff" bit. At the receive end, it will be removed and discarded by the demultiplexer. Circuitry associated with the input buffer detects the need for a "stuff" bit and requests this bit through the channel buffer control unit.

The 1.544935 Mb/s data streams from the up to eight channel buffers are synchronous and can be simply combined in the channel multiplexer. Identification of the stuff bits, plus the information required to recover the data from the separate T1 channels is added to the composite output in the control and framing subchannels. These are combined with the composite channel data in the frame multiplexer. The output of the frame multiplexer is approximately 1.57 Mb/s times the number of T1 input channels.

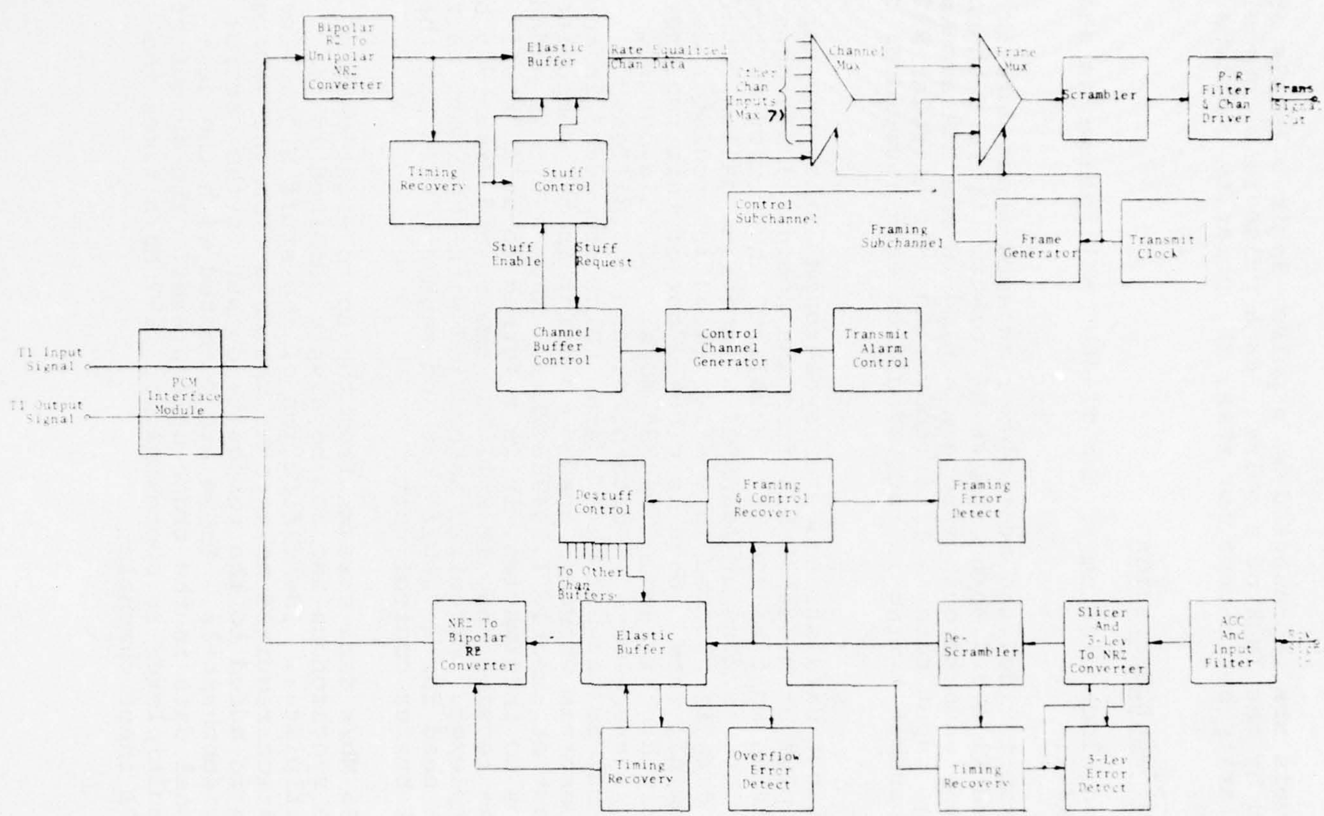


FIGURE A4-2. T1-4000 MULTIPLEXER SIMPLIFIED BLOCK DIAGRAM

The structure of the composite multiplexed output (for eight channels) is shown in Figure A4-3. The basic mux output (the main frame) is comprised of 130 bits as shown. The first bit is the framing bit. This bit alternates between a one and a zero from frame to frame. The framing bit is followed by 8 "words", each consisting of one bit from each of the input channels. Next a control bit is inserted (as discussed below) followed by an additional 8 channel data words.

Thirty-six main frames are combined upwards into a "control frame". The control frame is comprised of 36 main frames, and thus contains 36 bits each from the framing subchannel and the control subchannel. The framing bits simply alternate and are used by the receiver to locate the framing and control subchannels. The control bits are further organized into a 6-bit marker, eight 3-bit control words and six logic 0 bit that are not used. The marker bits may be transmitted as shown (011010) or inverted (100101). The latter case is interpreted by the receiver as an alarm condition.

The eight 3-bit control words are used to identify bits in the data stream which have been stuffed. Ones in the control bits signify that the bit in the next possible stuff position for that channel has in fact been stuffed. A zero indicates that the bit is valid T1 data. Majority logic is used in decoding the control bits to minimize the probability of loss of bit integrity due to an erroneous destuff operation.

The stuff position is always the same within the control frame, and is also shown in Figure A4-3. The last bit from channel 4 prior to the fifth framing bit in the control frame, and the first bits from channels 1, 2 and 3 are "possible stuff bits" as indicated by the associated control words.

Prior to transmission, the composite multiplexer output stream is convolved with a 7-bit pseudorandom sequence. This is done to remove any dc or other predominant spectral components introduced by the data input. This is accomplished by mixing the data stream, by means of an exclusive OR gate, with the output of a 3-bit pseudorandom generator. At the receiver the original sequence is recovered by performing the complementary function without need for any form of synchronization.

The scrambled binary NRZ data stream is converted to a form of partial response prior to output to the transmission media. The use of partial response coding significantly reduces the

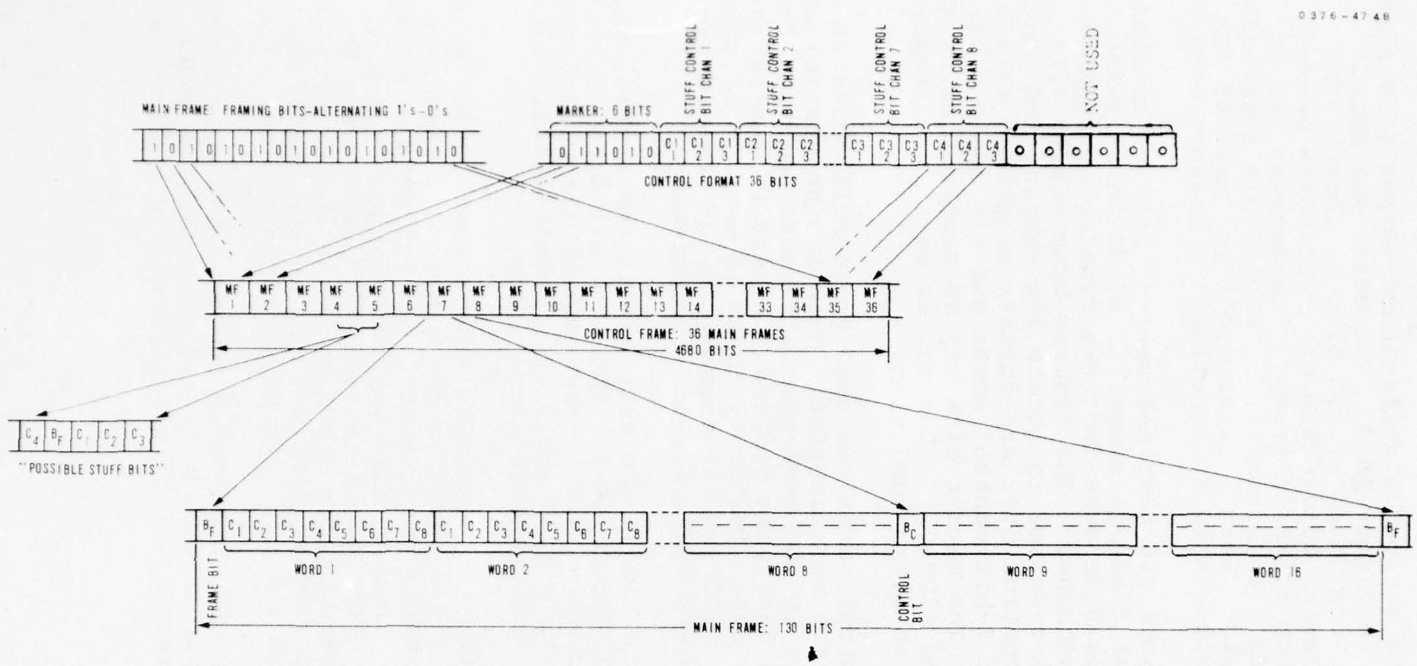


FIGURE A4-3. FRAMING STRUCTURE FOR T1-4000 MULTIPLEXER

transmission bandwidth requirements as compared to binary NRZ. The spectrum of the binary NRZ data is shown in Figure A4-4a. Note that it has a strong dc component.

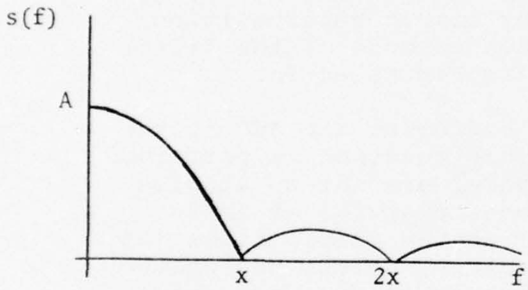
The first step in the transformation process is the removal of the dc component. The data stream is then passed through a low pass filter with the amplitude versus frequency characteristic shown in Figure A4-4b. Removal of the higher frequency components from the signal greatly slows the transition times, and spreads the response in time so that a degree of controlled intersymbol interference is introduced. This results not only in an interdependence of signalling elements, but also, since the symbols are linearly combined, yields three possible signal values at the bit times, instead of two. The pulse response of the filter is shown in Figure A4-5a for a single "one" pulse and two sequential "ones". Since the filter is linear, the composite output can be obtained by simple superposition of the individual pulse responses. The response of the filter to a typical binary sequence is shown in Figure A4-5b.

In the receiver, the first step after buffering and AGC is the recovery of the binary data stream. This function is performed by the slicer. Thresholds (slicer levels) are set up at plus and minus half the peak signal amplitude, that is, at $\pm A/2$. The value of the received signal level at the sample times (as determined by the timing recovery circuitry) determines whether the signal is a +1, 0 or -1. This sequence is then decoded to remove the controlled intersymbol interference introduced by the partial response coding.

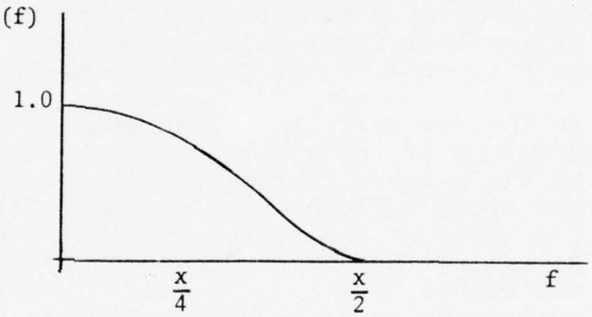
The rules followd by the receiver in decoding the 3-level signal are given below:

- The binary output is a 0 if the 3-level signal is a -1.
- The binary output is a 1 if the 3-level signal is a +1.
- The binary output is the opposite of that preceding if the 3-level signal is a 0.

An additional benefit of partial response channel coding is that only certain sequences of 3-level signal values are allowed. The state transition diagram for the Class I partial response signal generation is shown in Figure A4-6. Study of this diagram reveals the following constraints:



(a) Power Spectral Envelope of Binary Data Stream at x B/S.



(b) Amplitude Vs. Frequency Characteristic of Partial Response Filter.

FIGURE A4-4. SIGNALLING SPECTRA

AD-A033 538 HONEYWELL INC ST PETERSBURG FLA AEROSPACE DIV F/G 17/2

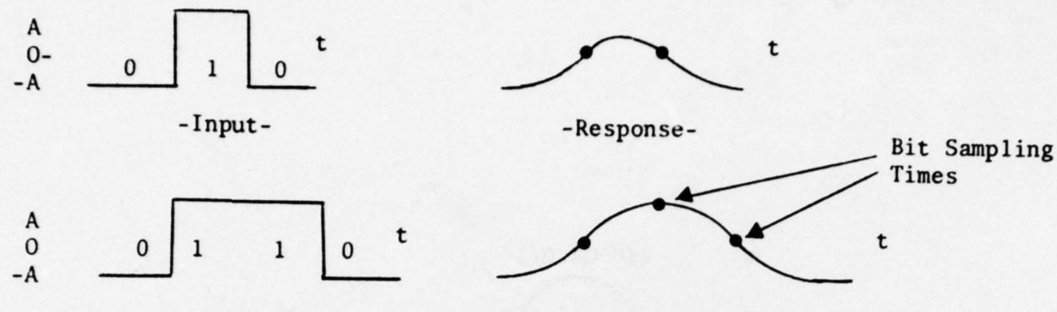
ATEC DIGITAL ADAPTATION STUDY. VOLUME I. FKV REQUIREMENTS FOR P--ETC(U)

OCT 76 T R ARMSTRONG, A K BLOUGH F30602-75-C-0282

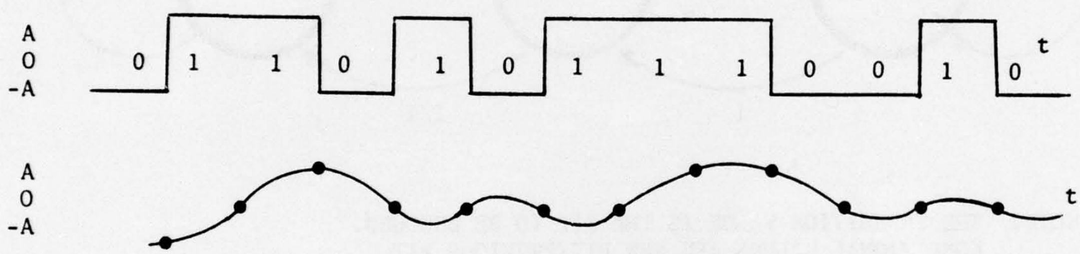
UNCLASSIFIED 476-13656-VOL-1 RADC-TR-76-302-VOL-1 NL

4 OF 5

ADA033538

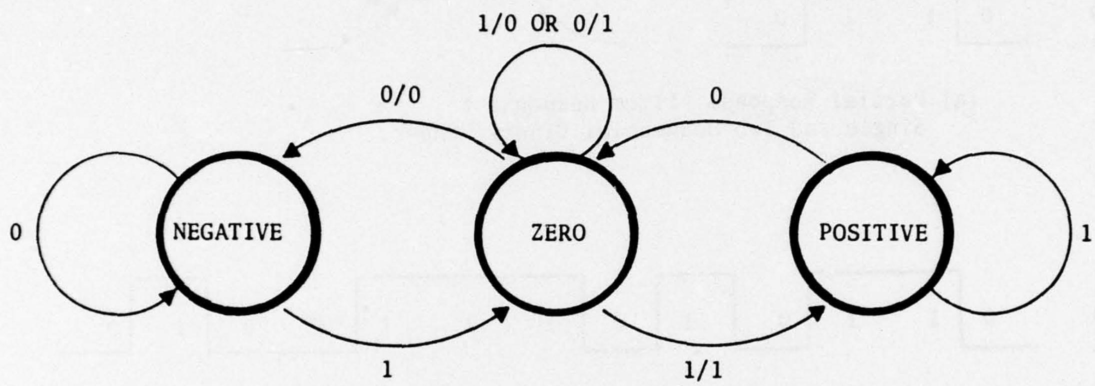


(a) Partial Response Filter Response to
Single and Two Sequential Binary "Ones".



(b) Partial Response Filter Response to
Typical Binary Waveform.

FIGURE A4-5. PARTIAL RESPONSE SIGNALLING WAVEFORMS



NOTE: THE TRANSITION VALUE IS THE BIT TO BE ENCODED. CONDITIONAL VALUES ARE NEW BIT/PREVIOUS BIT, THAT IS, 1/0 → THE BIT TO BE ENCODED IS A ONE, GIVEN THAT THE PREVIOUS BIT WAS A ZERO.

FIGURE A4-6. STATE TRANSITION DIAGRAM FOR CLASS I PARTIAL RESPONSE

(1) A positive peak at one bit time may not be followed by a negative peak at the next bit time and vice versa. Further, if a positive peak is followed at some later time by a negative peak, they must be separated by an odd number of center samples and vice versa.

(2) If a positive peak is followed at some time later by another positive sample, they must be separated by an even number of center samples. The same is also true for negative samples.

Errors in the received data stream, which occur when transmission perturbations cause the received signal level to cross a slicer threshold, have a fairly high probability of causing a sequence of 3-level symbols which violates the above constraints. The received sequences are monitored in the multiplexer, and can be extrapolated to give a good indication of the bit error rate.

The binary signal out of the slicer is next descrambled by convolving it with the same pseudorandom sequence used in the transmitter. Following this operation, the frame timing and control bits are recovered from the bit stream. The framing recovery circuitry simply searches the bit stream for the alternating 1-0 pattern, which identifies the framing and control bits. When transmission errors cause the loss of frame synchronization, a search is automatically started to recover it, and an alarm signal is generated.

The framing and control recovery circuitry provides control signals to the output buffers (one for each T1 channel in the multiplex configuration) to appropriately route the individual data bits. The destuff control causes stuff bits to be eliminated as required. Since the input to the output buffer may have abrupt discontinuities as framing, control, and stuff bits are deleted, it is designed to perform a smoothing function. A separate phase locked loop with a relatively narrow bandwidth is used to recover the average input bit rate. This stabilized clock is then used to strobe data out of the buffer. Alarm circuitry is provided to detect buffer overflow or underflow which may occur under certain error conditions.

The final stage of processing before the data is output is conversion of the unipolar NRZ data stream to the bipolar 50 percent duty cycle RZ form.

A4-1.3 Hardware Organization

The VICOM T1-4000 is housed in one terminal shelf unit. The top shelf mounts the common equipment, the lower shelves hold the channel related hardware. The four channel unit has two shelves; the eight channel unit has three.

The multiplexer has circuit modules of ten (10) different types in addition to the terminal shelf unit. Three module types are channel related with each duplex T1 channel having one each. They are the PCM Access Unit 4105, Transmit Channel Unit 4110, and Receive Channel Unit 4120.

The common units are Transmit Time Base 4021, Transmit Control Channel 4022, Interface Unit 4090, Receive Input Unit 4023, Receive Time Base Unit 4024, Receive Control Channel 4025, and Power and Alarm Unit 4010. Each T1-4000 has one each of these modules.

VICOM offers a test module that is not needed for operation. This is the Test Word Generator-Detector 4027.

A detailed description of the hardware implementation of the multiplexer is given in the following Paragraph A4-2.

A4-1.4 Protection Switch

The FKV communications network is protected from T1-4000 multiplexer failure by using standby equipment. Switchover to standby is automatically activated when main frame or control frame synchronization is lost in a receiver. The switchover is mechanized using the VICOM 4030 First Level Multiplexer Protection Switch.

A flow chart of the switchover sequence is given in Figure A4-7.

Switchover to the standby receiver is activated when the on line receiver loses main or control frame synchronization for more than 20 milliseconds.

The standby receiver is allowed to synchronize for 4.4 seconds. When synchronization is achieved, the transfer is latched and a minor alarm is generated by the protection switch.

The transfer can only be reset by manual or external logic command.

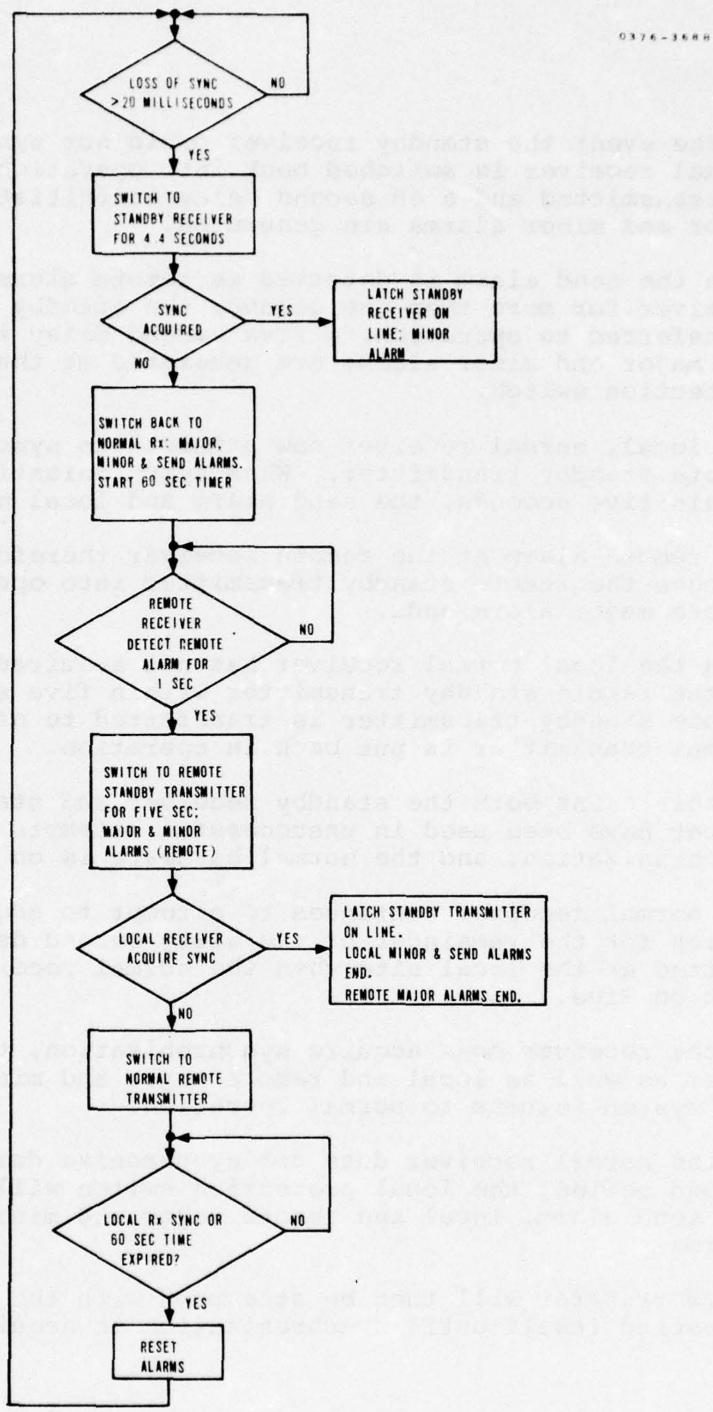


FIGURE A4-7. T1-4000 MUX PROTECTIVE SWITCH

In the event the standby receiver could not synchronize, the normal receiver is switched back into operation, a send alarm is transmitted and a 60 second delay is initiated. Also major and minor alarms are generated.

When the send alarm is detected as remote alarm at the remote receiver for more than one second, the standby transmitter is transferred to operation, a five second delay is initiated and major and minor alarms are generated at that site by the protection switch.

The local, normal receiver now attempts to synchronize to the remote standby transmitter. When synchronization is acquired within five seconds, the send alarm and local minor alarm ends.

The remote alarm at the remote receiver therefore ends. This latches the remote standby transmitter into operation. The remote major alarm ends.

When the local normal receiver has not acquired synchronization to the remote standby transmitter within five seconds, the remote standby transmitter is transferred to off line and the normal transmitter is put back in operation.

At this point both the standby receiver and standby transmitter have been used in unsuccessful attempts to acquire synchronization, and the normal hardware is on line.

The normal receiver continues to attempt to acquire synchronization for the remainder of the sixty second delay that was started at the local site when the normal receiver was put back on line.

If the receiver does acquire synchronization, the send alarm ends, as well as local and remote major and minor alarms. The system returns to normal operation.

If the normal receiver does not synchronize during this sixty second period, the local protection switch will reset ending the send alarm, local and remote major and minor office alarms.

A new transfer will then be attempted with the above sequence repeating itself until synchronization is acquired.

A special mode of operation exists when the operating multiplexer is placed in the loop mode. In this case the protection switch causes send alarm to be transmitted for 0.5 seconds followed by 0.5 seconds of no alarm ad infinitum. This modified send alarm inhibits transfer of the transmit multiplexer at the remote site.

A4-2 T1-4000 MULTIPLEXER; DETAILS OF HARDWARE IMPLEMENTATION

A4-2.1 Transmitter Operation

Figure A4-8 presents a block diagram of the T1-4000 transmitter, and also delineates the hardware modules.

The PCM Access Unit 4105 and Transmit Channel Unit 4110 are T1 channel related; the multiplexer has one unit for each T1 transmit channel. Half of the PCM Access Unit is used for the receive T1 channel corresponding to the other half of the full duplex channel.

The Transmit Control Channel Unit 4022, Transmit Time Base 4021 and Interface Unit 4090 are common to all channels.

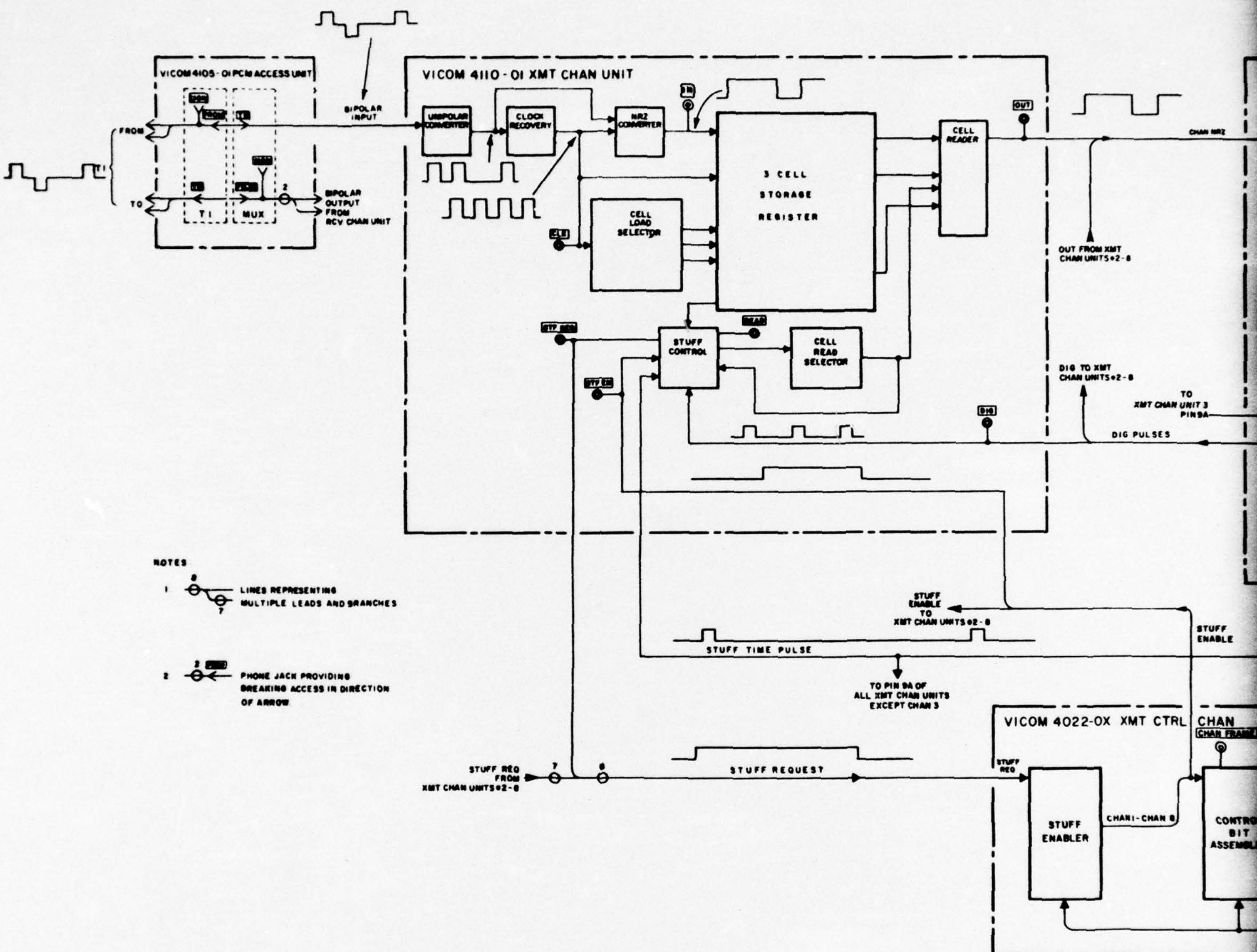
T1 channel connections are made to the multiplexer through back panel wiring to the PCM Access Unit. This unit provides for patching and monitoring of the T1 signals through six front panel phone jacks.

Two of the jacks provide for patching an alternate transmit and receive T1 channel to the multiplexer. A third jack provides monitoring access to the multiplexer T1 output.

Two other jacks provide patching to the transmit and receive T1 signals that are wired directly to the multiplexer. Insertion of the plug disconnects the signals from the multiplexer making the signals available for use in other equipment. A jack is available for monitoring the T1 signal that is normally transmitted by the multiplexer.

The input T1, bipolar signal is electrically unaffected by the PCM Access Unit. The transmit signal is buffered by the unipolar converter located on the Transmit Channel Unit 4110.

The unipolar converter consists of a resistor network in parallel with the primary of a transformer, and presents a 100 ohm, balanced input impedance.



VICOM 4105-01 PCM ACCESS UNIT
FROM
TO
T1
MUX
BIPOLAR INPUT
BIPOLAR OUTPUT FROM RCV CHAN UNIT
VICOM 4110-01 XMT CHAN UNIT
UNIPOLAR CONVERTER
CLOCK RECOVERY
NRZ CONVERTER
3 CELL STORAGE REGISTER
CELL READER
OUT
CHAN NRZ
CELL LOAD SELECTOR
STUFF CONTROL
CELL READ SELECTOR
OUT FROM XMT CHAN UNITS #2-8
DIG TO XMT CHAN UNITS #2-8
TO XMT CHAN UNIT 3 PIN 9A
DIG PULSES
STUFF ENABLE TO XMT CHAN UNITS #2-8
STUFF ENABLE
STUFF TIME PULSE
TO PIN 9A OF ALL XMT CHAN UNITS EXCEPT CHAN 3
STUFF REQ FROM XMT CHAN UNITS #2-8
STUFF REQUEST
VICOM 4022-0X XMT CTRL CHAN
STUFF REQ
STUFF ENABLER
CHAN1-CHAN 8
CONTROL BIT ASSEMBL
NOTES
1 LINES REPRESENTING MULTIPLE LEADS AND BRANCHES
2 PHONE JACK PROVIDING BREAKING ACCESS IN DIRECTION OF ARROW

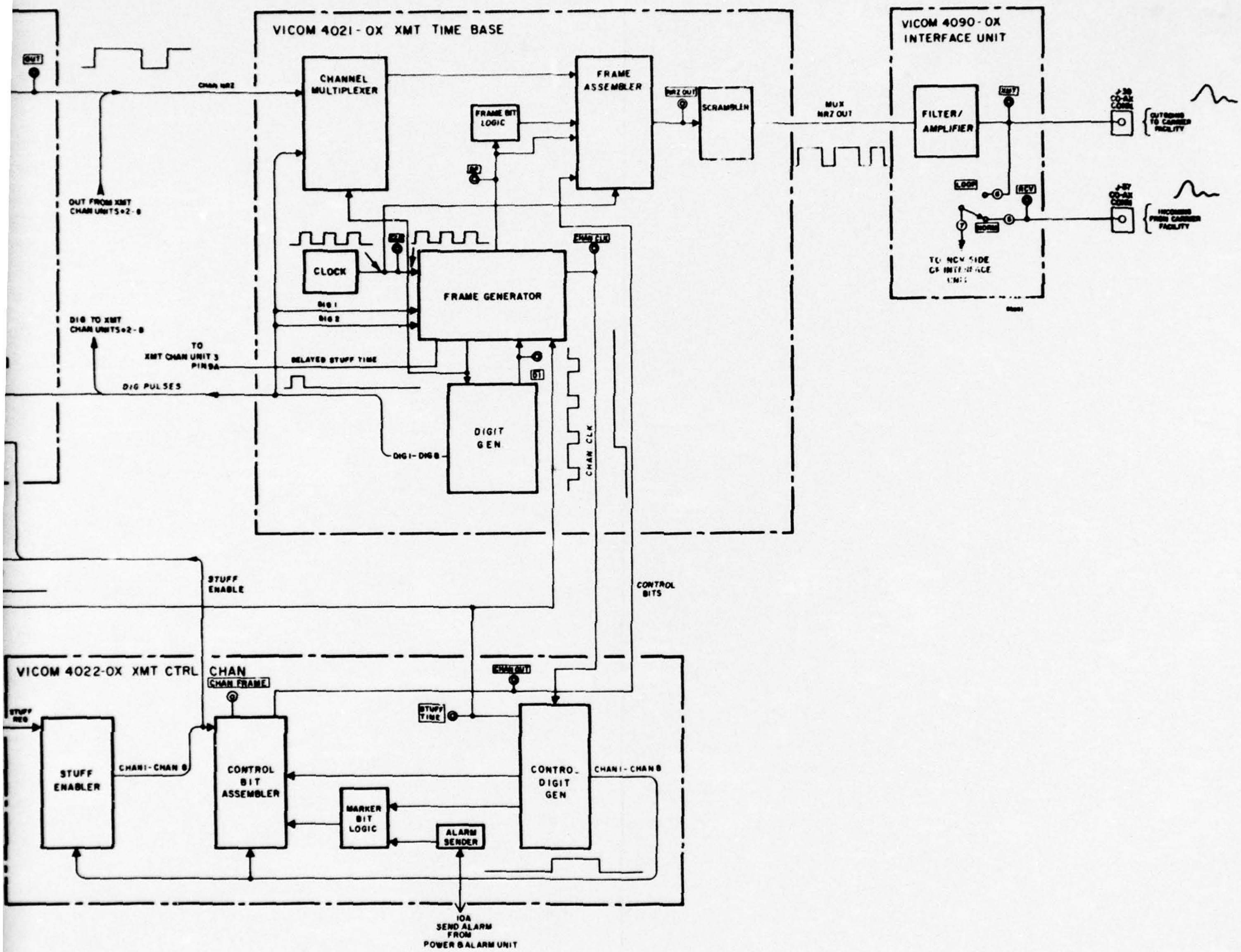


FIGURE A4-8. T1-4000
TRANSMITTER BLOCK DIAGRAM

The secondary of the transformer is center tap grounded with its two outputs used as the inputs of a NOR gate. At the output of this gate, the T1 signal is in unipolar, 50 percent return to zero format.

Clock is recovered from this signal by using it to drive a transistor circuit containing an RLC tank circuit timed to 1.544×10^6 Hz. Automatic gain control is employed to maintain signal level in the tank circuit as the transition rate varies due to data content.

The T1 signal used to drive the clock recovery circuit is latched into a flip flop using the recovered clock. The output of the flip flop is the T1 data in non-return to zero (NRZ) form.

The NRZ data is loaded into one cell of a three flip flop register by the opposite polarity clock. The data is supplied to all three flip flops in parallel, but only one is clocked. A three state counter which is driven by the recovered clock controls the write location. NOTE: New versions of the multiplexer have an eight bit buffer; operation is similar.

The data is read out of the register at approximately 1,544,935 bits/second under control of a clock signal (DIG) from the Transmit Time Base. The cell to be read is selected by a three state counter identical in form to the write counter.

When a bit is being read from the first flip flop in the storage register, a check is made to determine if the second flip flop is the next write location. When the check proves this to be the case, a Stuff Request is generated and latched. The Stuff Request is used in the Transmit Control Channel Unit 4022 to control the stuff code transmitted in the control frame format for that T1 channel.

The clock that reads the T1 data out of the storage register is designated DIG and is generated in the Transmit Time Base 4021 from the basic transmitter clock.

The basic clock source is a discrete transistor, crystal controlled oscillator at a frequency of 12.5526×10^6 Hz for the eight channel multiplexer. The four channel version runs at 6.2763×10^6 Hz.

A separate storage register read clock (DIG) is generated for each T1 channel. The signal is normally a logic 0 that has a logic 1 pulse when the storage register is read. The logic 1 pulse width is normally one bit wide in reference to the multiplexed bit rate. The pulse for channel one is followed by the pulse for channel 2, etc. as shown in Figure A4-9. The figure applies to the four channel case.

The DIG 1 signal has a logic 1 pulse that is two bits wide each time a main framing bit or control bit is transmitted.

The DIG generator is a ring counter of strappable length depending upon the number of channels to be multiplexed.

The Transmit Time Base Unit provides the other basic timing functions for the transmitter. It also contains the multiplexer that formats T1 bits from each channel, main framing bits, and control bits into a serial bit stream with the frame organization previously described. The flip flop that generates the alternating pattern for the main framing bits is also located in this unit.

The T1 data for each channel is transferred to the multiplexer in parallel. The DIG signals are used to control the multiplexer and increment the individual storage register read counters as previously described.

A word counter controls the insertion of main framing bits and control bits.

The serial, multiplexed bit stream is scrambled before transmission to reduce dc or other strong frequency components in the baseband. The scrambling is implemented by an exclusive OR of the bit to be transmitted with the bits transmitted two and three bits previously. This technique allows the receiver descrambler to synchronize automatically in three bit times. However, this technique propagates a one bit transmission error into three errors due to the fact that each bit is used in the descrambler three times.

The Transmit Time Base Unit supplies $\overline{\text{CHAN CLK}}$ which is the basic clock for control and formatting of the control bits in the Transmit Control Channel Unit.

The $\overline{\text{CHAN CLK}}$ is normally a logic 1 that has a logic 0 pulse that straddles the main framing bit. The $\overline{\text{CHAN CLK}}$ falls at the fall of DIG 2 and rises at the next DIG 2 fall, but only when a main framing bit intercedes.

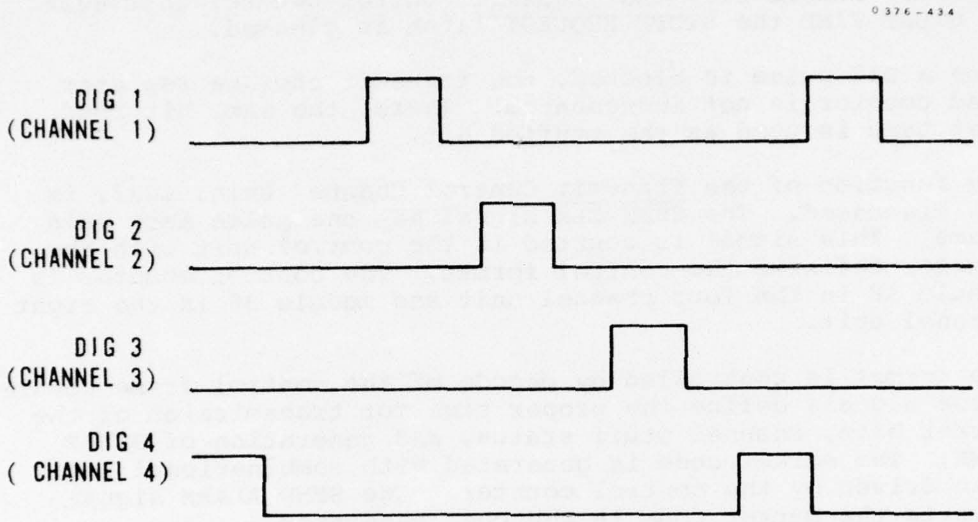


FIGURE A4-9. TRANSMIT STORAGE REGISTER CLOCK; FOUR CHANNEL CASE

The STUFF TIME signal, generated in the Transmit Control Channel Unit 4022, occurs simultaneously with $\overline{\text{CHAN CLK}}$ but of opposite polarity, and it occurs only between the fourth and fifth marker bits of the control frame. The STUFF TIME signal is used in the Transmit Channel Unit 4110 to block one DIG pulse when a STUFF REQUEST has been generated and acknowledged by STUFF ENABLE from the Transmit Control Channel Unit 4022. At STUFF TIME the STUFF REQUEST latch is cleared.

When a DIG pulse is blocked, the transmit storage register read counter is not incremented. There, the same bit read last time is used as the stuffed bit.

The function of the Transmit Control Channel Unit, 4022, is now discussed. The $\overline{\text{CHAN CLK}}$ signal has one pulse each main frame. This signal is counted in the control unit with the counter defining the control format. The control counter is modulo 18 in the four channel unit and modulo 36 in the eight channel unit.

The format is controlled by decode of the control frame counter. These signals define the proper time for transmission of the marker bits, channel stuff status, and generation of STUFF TIME. The marker code is generated with combinational logic also driven by the control counter. The SEND ALARM signal inverts the marker code in the code generator.

The individual STUFF REQUEST signals from each transmit channel are latched in separate flip flops. The output of the flip flops is the STUFF ENABLE signal sent back to the requesting channel unit. Each flip flop is clocked separately using the signal that opens the control multiplexer to that channel's stuff status.

The STUFF ENABLE signal is transmitted as the three bit stuff status.

The control bits are presented serially to the Transmit Time Base 4021 for multiplex into the transmitted bit stream.

The transmitted bit stream is supplied to the Interface Unit 4090 for signal conditioning in preparation for transmission.

The transmission technique is duobinary, three level partial response. This is implemented by frequency domain filtering the non-return to zero bit stream. Half of the filtering is in the transmitter and half in the receiver.

The transmit and receive filters are similar in form, consisting of a transistor circuit containing a low pass LC filter. The transmitter output is AC coupled eliminating circuit DC, as well as, the DC components of the baseband data.

The theoretically correct filtering for duobinary is a frequency spectrum having the shape of a cosine function with the zero crossing at a frequency of one half the bit rate. This frequency spectrum corresponds to the total effect of transmitter filter, transmission media, and receive filter. This function does have a dc component.

The output of the transmitter is a Darlington pair, emitter follower transistor amplifier with output impedance set at 75 ohms by a series output resistor.

The amplitude of the output signal is controlled by selecting a resistor in the output filter.

The interpretation of three level partial response signals at the receiver is complicated by the intersymbol interference introduced in the transmitter. In particular, of the three levels received, only two are unique. The third level requires knowledge of the binary level previously received to properly decode the bit in question.

Because of this, a bit error due to transmission anomalies can be propagated to several errors in the receiver.

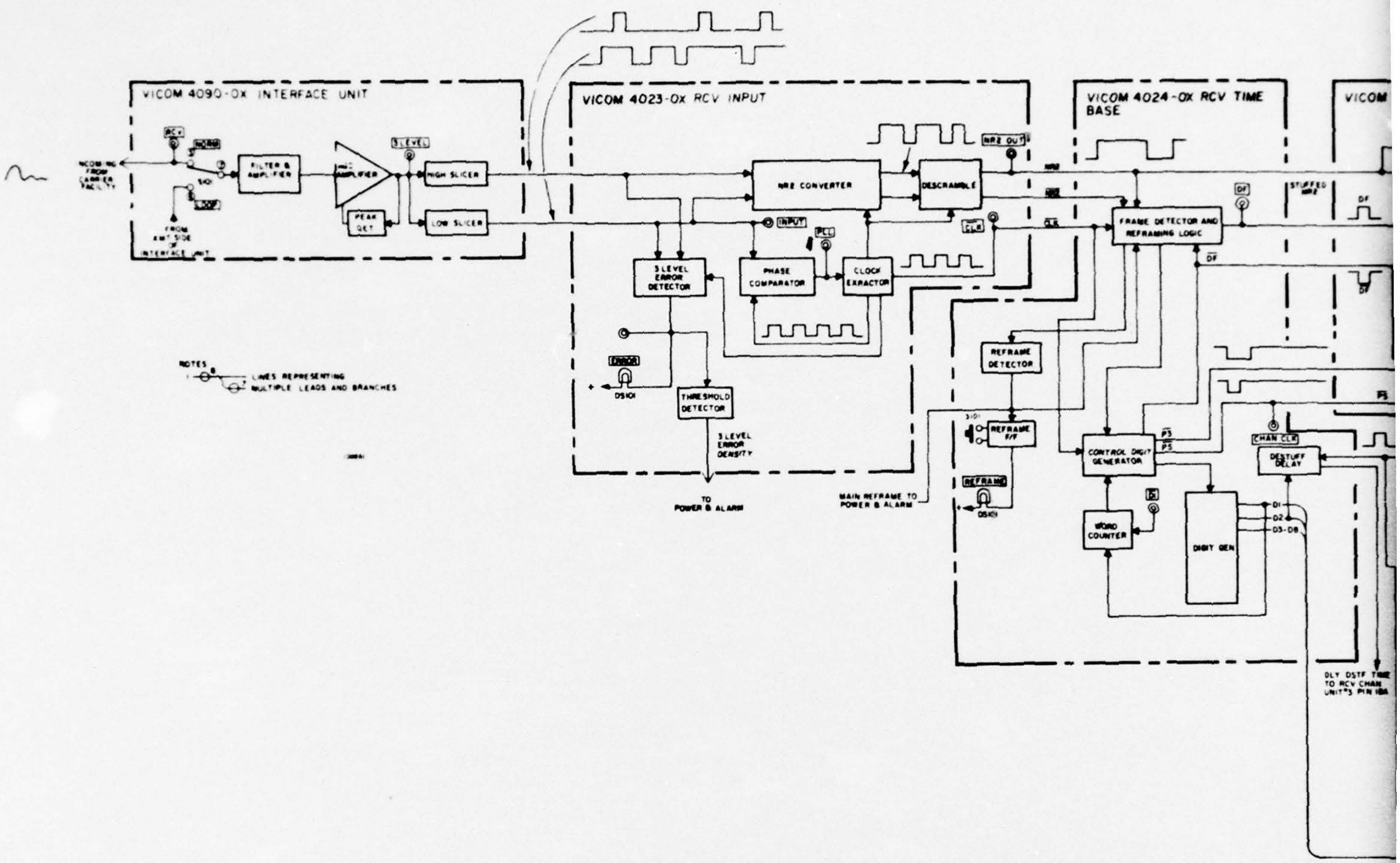
A technique, called precoding can be employed in the transmitter so that each receive level is unique, and thereby eliminating error propagation.

Precoding is not employed in the VICOM unit, and therefore propagating errors will occur.

A4-2.2 Receiver Operation

A block diagram of the VICOM T1-4000 receiver is presented in Figure A4-10.

The partial response signal is received by the partial response filter. The filter output is amplified by an automatically gain controlled amplifier, and compared to two thresholds. The output of the threshold detectors (slicers) is binary. The low level slicer output is used in a phase locked loop to derive a bit rate clock.



VICOM 4090-0X INTERFACE UNIT
FILTER & AMPLIFIER
HIGH SLICER
LOW SLICER
PEAK DET
VICOM 4023-0X RCV INPUT
NRZ CONVERTER
DESCRAMBLE
NRZ OUT
INPUT
PLL
3 LEVEL ERROR DETECTOR
PHASE COMPARATOR
CLOCK EXRACTOR
ERROR
DS101
THRESHOLD DETECTOR
3 LEVEL ERROR DENSITY
TO POWER & ALARM
VICOM 4024-0X RCV TIME BASE
FRAME DETECTOR AND REFRAMING LOGIC
DF
REFRAME DETECTOR
REFRAME F/F
REFRAME
CONTROL DIGIT GENERATOR
CHAN CLK
DESTUFF DELAY
WORD COUNTER
DIGIT GEN
D1
D2
D3-D8
MAIN REFRAME TO POWER & ALARM
DLY DSTF TIME TO RCV CHAN UNIT#3 PIN 18A
VICOM
NOTES
LINES REPRESENTING MULTIPLE LEADS AND BRANCHES

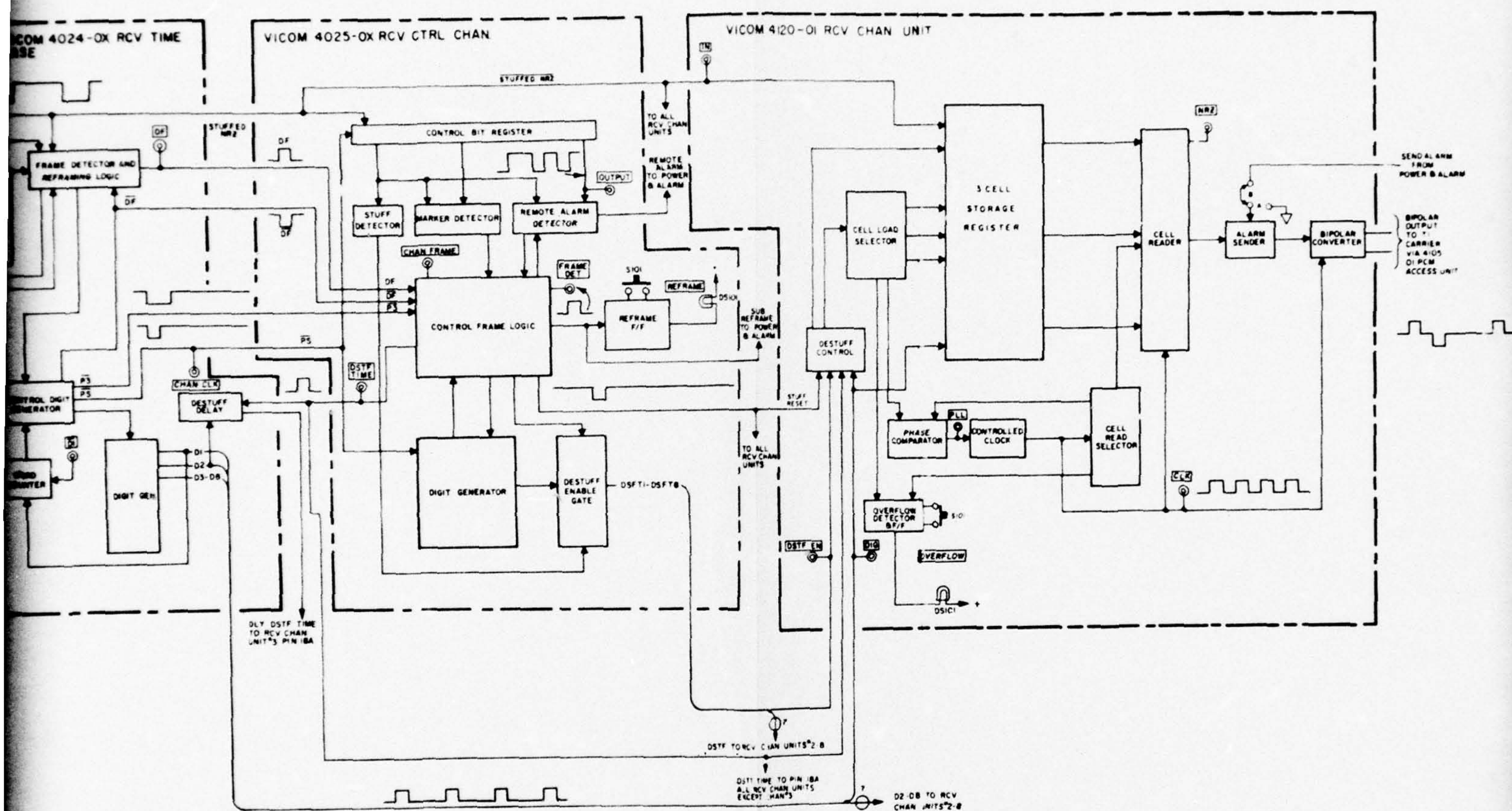


FIGURE A4-10. T1-4000 RECEIVER

2

Using this clock, the two slicer outputs are decoded into a single bit stream that is a replica of the transmitted bit stream. This signal is descrambled and presented to the main frame synchronization circuitry.

After main frame synchronization is acquired, the transmitted bit stream is demultiplexed and destuffed. Control frame synchronization and destuff control is performed in the Receive Control Channel Unit 4025.

Each receive channel has a three cell storage register that operates similarly to the transmit storage registers. NOTE: New units incorporate an eight cell buffer. Clock for reading the contents of the register to the T1 channel is derived from the received data using a phase locked loop. This clock is not supplied to the T1 channel with the data.

The partial response signal from the radio is received by a transistor stage of the 3 level response shaping filter. This filter is a low pass LC. The LC filter output is an emitter follower Darlington pair of transistors which supplies a high impedance load to the filter.

The Darlington pair drives an operational amplifier circuit that has automatic gain control implement with discrete transistors. The gain control circuit controls peak amplitude at the output of the amplifier. The control signal is in current form.

The amplitude controlled signal is compared to reference levels of +0.75 and -0.75 volts in two comparators, designated high and low slicers in Figure A4-10. The output state of the two comparators continuously indicate which of three bands of amplitude the signal has taken.

These two signals are used in the Receive Input Unit 4023 to decode the three levels of partial response into a binary bit stream. The slicer signals are also used to derive a bit rate clock using a phase locked loop that selects the optimum time to sample the slicer signals for decode.

The phase locked loop consists of a voltage controlled crystal oscillator, digital phase comparator and phase error integrator. The crystal controlled oscillator is implemented with discrete transistors with a voltage variable capacitance diode as the control element. The nominal rate of the oscillator is 12.5526 MHz for the eight channel multiplexer and 6.2763 MHz for the four channel unit.

The phase comparator consists of a TTL one shot, 74121N, that is triggered by a falling edge at the low slicer output. The one shot output is compared to the clock signal, and its reverse, in two TTL NOR gates. One of the NOR gates drives a discrete transistor circuit that charges an RC circuit. The other NOR gate drives a similar circuit that discharges the capacitor through a separate resistor. The voltage on the capacitor resistively coupled to the voltage controlled oscillator as the frequency control signal.

The loop functions by matching the charge and discharge time of the phase error capacitor by the two segments of the phase comparator. The RC time constant is 10^{-5} for both.

The phase locked clock and the slicer data is passed through several TTL gates that act only as delay elements. The nominal delay from the inputs of the slicers to the input of the flip flop that is used to clock the data is 80 nanoseconds, or approximately one bit time at 12.55 Mb/s.

The resistor in the one shot timing circuit is selected to accommodate differential delay between the data and clock paths.

The phase of the data to clock at the flip flop will change with temperature and time as the time delays change. Replacement of hardware in maintenance operations may affect timing if the one shot is not recalibrated.

It should be noted that the clock and data signals used for the phase comparison are not the signals at the flip flop input where the sampling is made. Instead the phase comparison is several devices preceding the decision making flip flop.

The output of the decision flip flop is a reproduction of the transmitted NRZ bit stream. This signal is used in a three stage shift register to descramble the bit stream. This circuit will propagate one bit transmission error into three bit errors. The descrambled bit stream is bused to the main frame and control frame synchronization circuits as well as the receive channel storage registers.

A three level error detector operates in parallel to the partial response decode logic and decision flip flop.

This circuit monitors for violations in the decoded partial response format. In particular, an odd number of time slots should exist between the two extreme levels under error free conditions. Also, an even number of time slots should exist between consecutive occurrences of the same extreme level. The three level error detector monitors for violations of this condition.

Violation indicates an error in transmission that may cause an error in decode. However, no attempt is made to correct the error when detected.

With certain data combinations, the violation detectors offsets the data in time relative to the clock. This gives a predictive character to the detector.

The output of the three level error detector drives two circuits made up of discrete transistors. One circuit is a one shot lamp driver. Each detected error activates the one shot that in turn pulses a lamp on the Receive Input Unit 4023 front panel.

The other circuit averages the three level error rate. The output of this circuit is the "3 LEVEL ERROR DENSITY" signal that is used in the Power and Alarm Unit.

The averaging portion of the circuit consists of a capacitor with different charge and discharge time constants. The discharge time constant, which corresponds to detected errors, is 470 nanoseconds. The charge time constant is 846 microseconds when the 3 LEVEL ERROR DENSITY signal is a logic 0, and approximately 423 microseconds when a logic 1. A minor alarm corresponds to a three level error rate of 10^{-5}. However, the minor alarm relay chatters and does not remain on until the violation rate exceeds approximately 10^{-3}.

The output of the descrambler is used in the Receive Time Base 4024 with the derived clock to synchronize to the main frame format. This unit also contains the circuitry that generates the receiver DIG signals, and the main frame word counter. The characteristics and function of the receiver DIG signals are similar to the transmitter DIG signals.

The DIG 1 signal is counted by the word counter, which is decoded to generate DF and $\overline{PS}$. These two signals indicate the time of the expected main frame framing bit, and control bit respectively.

The main frame synchronization process starts after detection of loss of synchronization. No master reset or power reset is used.

The circuitry that monitors for loss of main frame synchronization consists of a toggle flip flop, exclusive OR function, and analog counting circuit. The toggle flip flop produces the dotting pattern that is expected to be received for the framing bit. Its output is compared to the descrambler output at the time indicated by the DF signal. Another flip flop is used to latch the results of the comparison. Its output drives a transistor circuit similar in form to the one used to count three level errors in the Receive Input Unit. The output of the counter, MAIN REFRAME, is latched and drives a front panel lamp. The latch is reset using a front panel switch. The MAIN REFRAME signal is also used in the Power and Alarm Unit.

When MAIN REFRAME is a logic 1 and the last framing bit miscompared, the next DIG 2 signal remains a logic 1 for clock periods instead of one. This delays the assumed main framing bit location by one bit.

As this is being done, the toggle flip flop that predicts the level of the next framing bit, is set to the logic level of the descrambler output at the first DIG 1 following the miscompared framing bit. This bit is the new assumed framing bit. The circuitry is now prepared to monitor the next assumed framing bit and to repeat the above process.

When the assumed framing bit has the expected logic level, no shift is made.

The synchronization criteria for main frame is implemented with an analog circuit which is distribution sensitive. Following a long loss of synchronization, the MAIN REFRAME signal will indicate sync after approximately one millisecond of solid synchronization.

Loss of synchronization indication is given with receipt of five incorrect framing bits in a row; fifteen incorrect framing bits out of 100 will also cause loss of sync.

The $\overline{\text{PS}}$ signal is used to clock the control bits into a six bit shift register. When attempting to synchronize, the contents of the register is checked for the marker code after the receipt of each new control bit. When the marker, or its inverse, is detected, the control counter is set to a count of four. This counter counts the $\overline{\text{PS}}$ clock and is decoded to

determine the position of the received bits in the control format. The counter is modulo 18 for the four channel case and modulo 36 for the eight channel case.

When the next assumed marker bits are received and decoded as a marker, a flip flop is set. Following this, two consecutive imperfect markers are required to cause a control reframe.

The control reframe signal is sent to the Power and Alarm Unit and is named SUB REFRAME. This signal is also latched in the Receive Control Channel Unit 4025, where it is generated, and used to drive a front panel lamp. This latch can be reset using a front panel switch.

The next three control bits following the marker are the stuff status for channel one. These three bits are shifted into the first three cells of the six cell control shift register. Under control of the control counter, these three bits are majority voted at the appropriate time and the $\overline{\text{DSTF ENABLE 1}}$ signal is pulsed if the next stuff bit is to be discarded.

The $\overline{\text{DSTF ENABLE 1}}$ signal is latched on the Receive Channel Unit 4120. The $\overline{\text{DSTF ENABLE}}$ signal of each channel is decoded in a similar manner.

A signal defining when stuff bits are received, DSTF TIME, is generated by decoding the control counter and clocking the decode with $\overline{\text{P3}}$ from the Receive Time Base 4024.

When DSTF TIME occurs, each channel unit that has latched the $\overline{\text{DSTF ENABLE}}$ command will block one DIG pulse. This will disallow the three cell storage register from loading the stuff bit and will not increment the write counter. The Receive Control Channel Unit 4025 will generate a $\overline{\text{STUFF RESET}}$ at receipt of the sixth marker bit. This signal will clear the DSTF ENABLE latches in preparation for receipt of the new destuff status.

When a control marker is detected that is inverted bit by bit, the REMOTE ALARM signal is generated and latched by the Receive Control Channel Unit. The status of this latch is updated at receipt of each marker.

Each receive T1 channel has a separate three cell storage register, destuff control, and phase locked loop contained in separate Receive Channel Units 4120. The function of this unit is the dual of the Transmit Channel Unit 4110 in the transmitter.

Data is written into the register at 1,544,935 bits/second under control of the DIG signals generated in the Receive Time Base 4024. The DIG signal drives a write counter that steps the write location each received bit. A stuffed bit is discarded by blocking its corresponding DIG signal as previously described.

The T1 data is read out of the register and multiplexer by a clock derived using a phase locked loop. This clock is counted in a three state read counter that controls a digital multiplexer. The multiplexer enables the appropriate output of the storage registers with its output clocked into a flip flop. NOTE: New units have an eight cell buffer and eight state counters.

The flip flop output is used in a transistor/transformer circuit to generate the 50 percent bipolar T1 output having an output impedance of 100 ohms balanced.

The phase locked loop is similar to the one in the Receive Input Unit 4023 that derives clock from the three level signal. The major differences, besides time constants, is that an operational amplifier is used to buffer the phase error voltage before it is supplied to the voltage controlled oscillator, and the phase comparator does not have a one shot.

The phase comparator consists of two gates connected as a latch. Each gate drives separate transistor stages. One stage charges the phase error integrator, the other stage discharges it.

The function of the latch is to latch in one of its states as the write counter reaches the binary 10 position and latch in the other state when the read counter reaches 10. The function of the loop is to maintain the storage register half full, on the average. Therefore, the latch should be in each state half the time.

When the average is not half, the phase error integrator will be charged and discharged unequal amounts of time and will develop a different DC voltage. This voltage is buffered by an operational amplifier and supplied as the control voltage to the voltage controlled oscillator. Thus closing the loop.

The charge and discharge time constant of the phase error capacitor is 224 microseconds, for the three cell case.

The phase error voltage from the operational amplifier is made available at a test point.

The read and write counters for the storage register are monitored for overflow. An overflow condition sets a latch that drives a front panel lamp; a front panel switch resets the latch.

The local SEND ALARM forces the receiver T1 outputs to a logic 1. This produces a sequence of opposite polarity pulses at the T1, 50 percent bipolar output as is appropriate for constant logic 1 data.

A4-2.3 Power and Alarm Unit

The Power and Alarm Unit 4010 has two versions, the -01 and -02. The -01 uses 115 volts AC, 60 Hz as primary power source; the -02 uses -48 or -24 volts DC.

The dc outputs of both units are +20, +12, +5, and -6 volts. The +20 volt DC output is not regulated; the other outputs are.

A schematic of the alarm portion of the Power and Alarm Unit is presented in Figure A4-11. Table A4-2 presents the internal conditions that will generate an alarm.

A send alarm and major alarm is generated when either a MAIN REFRAME or SUB REFRAME (control reframe) is indicated for 250 milliseconds. NOTE: In the FKV, SEND ALARM is generated by the protective switch and not the multiplexer. As shown in Figure A4-11, the time delay is implemented by discharging a capacitor at the base of a transistor with a time constant of 62.5 milliseconds. A major alarm is also generated by receipt of a remote alarm or by loop alarm.

A minor alarm is generated by a three level error rate of 10^{-5} in the partial response demodulator.

A local send alarm is the dual of a remote alarm.

The major alarm relay contacts are rated at 2.0 amperes; minor alarm contacts at 0.5 ampere.

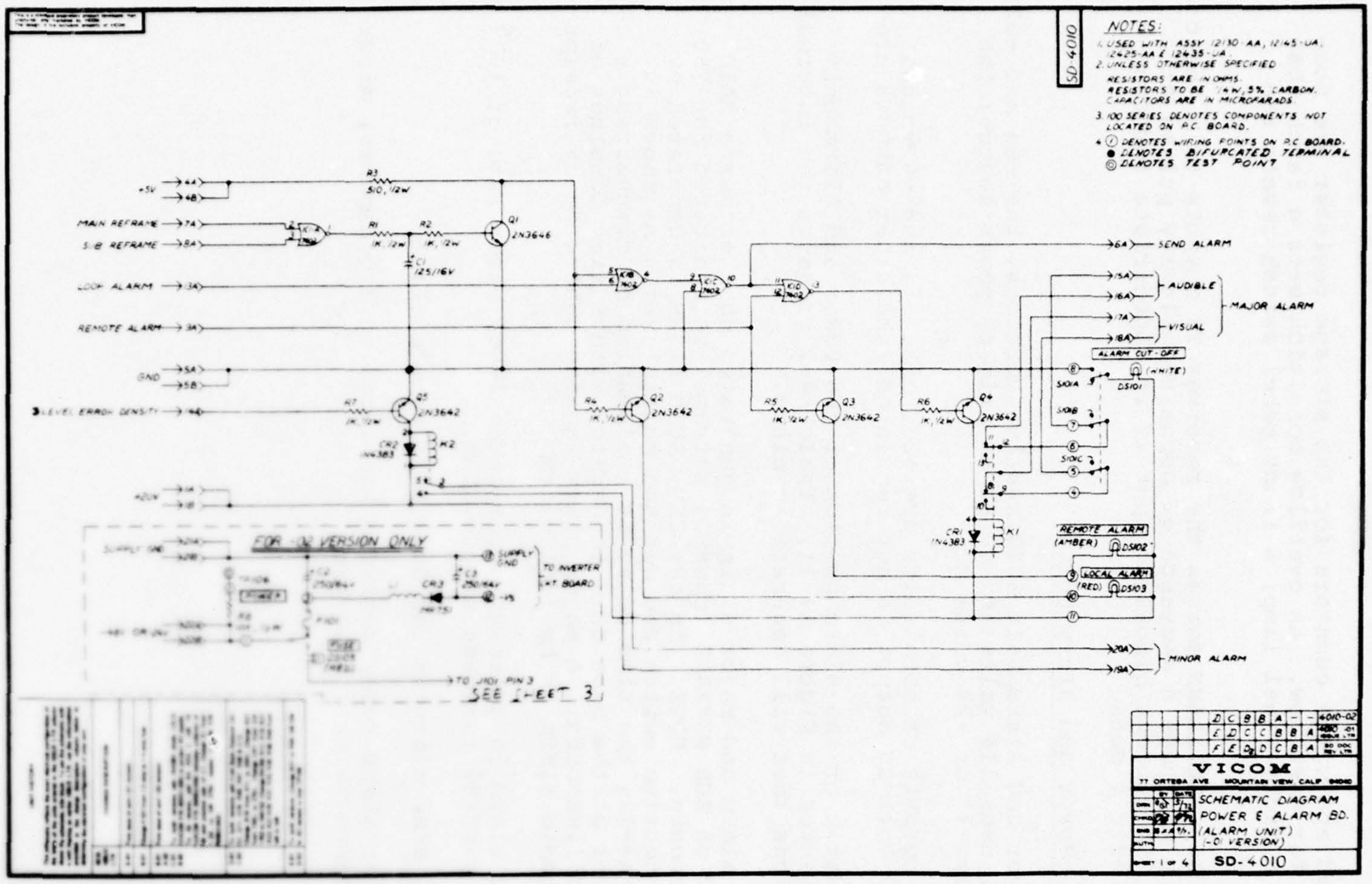


FIGURE A4-11. SCHEMATIC DIAGRAM POWER AND ALARM BOARD (ALARM UNIT) (-01 VERSION)

TABLE A4-2. ALARM INDICATIONS

		Inputs to Power and Alarm Unit					
		Loop Alarm	3-Level Error Density	Main Reframe	Sub Reframe	Remote Alarm	+20 Vdc
Outputs From Power And Alarm Unit	Send Alarm	X		X	X		
	Minor Alarm		X				
	Major Alarm	X		X	X	X	X

A4-3 CANDIDATE T1-4000 TDM MONITOR POINTS

Candidate T1-4000 Receiver Monitor Points

1. Three Level Partial Response Input

   a. Electrical: 75 ohms, unbalanced. The signal is cabled to the multiplexer using coaxial cable to Jack J37. This signal could be monitored using a high input impedance buffer in parallel with the cable connection.

   b. This signal is an analog representation of the baseband data. In this format various measurements could be made to assess transmission performance, analyze trends, and isolate faults. Indeed, this may be the one most significant monitor point in the system. Due to the anticipated amount of coverage of this signal in other parts of the study, it will not be expanded here.

2. Three Level Partial Response After Filtering

   a. Electrical: The analog signal is not presently available at a connector. The signal is on the Interface Unit 4090. It would have to be buffered before exiting the unit.

   b. The output of the receiver filter is the first signal that has the three level partial response format. The reason for this is that half of the partial response filtering is done in the receive filter.

      The characteristics of this signal are similar to those at the input of the multiplexer and has similar usefulness for monitoring with the added feature of the capability to detect filter degradation.

      The availability of the partial response signal at the output of the AGC circuit makes this signal an unlikely candidate for monitoring.

3. Three Level Partial Response After AGC

   a. Electrical: This signal is available at TP104 on the Interface Unit 4090. A one thousand ohm resistor isolates the test point from the three level partial response signal.

b. The output of the AGC circuit is the three level partial response signal that is compared to two levels in the slicers. This conditional analog signal is the last appearance of the data in analog form.

Because the AGC output is the end output of the analog transmission path, this could be a most useful monitor point. It is this signal whose eye pattern is of most significance system wise, because it is the signal that is sliced. The characteristics of the baseband signal out of the radio receiver contains more information about transmission performance, but the conversion to digital data is made following the filter and AGC.

Eye pattern degradation and signal peak level could be monitored.

Since the information is contained in the amplitude of the signal relative to the slicer levels, the peak amplitude is a significant parameter.

4. AGC Control Signal

a. Electrical: This signal is available as a voltage at the emitter of an NPN transistor (Q12) on the Interface Unit 4090.

b. It reflects the received signal level, with the voltage decreasing with increase in signal level.

5. High and Low Slicer Outputs

a. Electrical: The low slicer output signal is available as a TTL signal at the Interface Unit 4090 connector, pins 21 A & B, and the Receive Input Unit 4023 connector, pin 7A. This signal is also available at TP104 on 4023, but is of opposite logic polarity.

The high slicer output signal is available at the Interface Unit 4090 connector, pins 20 A & B, and at the Receive Input Unit 4023 connector, pin 7B. No test point is available.

b. The significance of these signals is that they are digital (after analog to digital conversion) and have not yet been retimed. Therefore, inaccuracies in transmission, and interpretation in the receiver, will appear as a variation of the occurrence of transitions with

respect to the expected occurrence. Jitter in these signals corresponds to eye pattern degradation of the analog signal.

6. Derived Clock (Receiver Input)

   a. Electrical: A clock signal is used to strobe the decode of the slider levels into a flip flop. Following this point, the data is processed using a clock.

      The derived clock signal, CLK, is available at TP104 and connector pin 8A of the Receive Input Unit 4023. The data is checked at the fall of this signal.

   b. The clock is derived using a voltage controlled crystal oscillator in a phase locked loop that tracks the phase of the low level slicer transistors.

      The phase comparator contains a low pass filter with a single break point at 10^5 Hz.

7. Phase Error for Derived Clock (Receiver Input)

   a. Electrical: The phase error signal from the phase locked loop mentioned in 6. is made available at TP105 on the Receiver Input Unit 4023. The test point is isolated from the active signal by a 1000 ohm resistor.

   b. The phase error signal is the output of a low pass filter having a break frequency of 10^5 Hz. The amplitude of this signal could be monitored to determine the jitter of the signal at the low slicer output.

8. Three Level Violation Detector

   a. Electrical: Violations in the receipt of the three level partial response signal are detected by the VICOM multiplexer on the Receive Input Unit 4023.

      Each detected error causes a TTL logic 1 pulse at TP106 on the Receive Input Unit 4023. The duration of this pulse is one bit time.

      This signal is processed in the receive input unit to generate a Three Level Error Density signal at connector pin 21A. This signal becomes a logic 1 when the detected violation rate exceeds 10^{-5}. This signal triggers a minor alarm.

b. The Three Level Error Density signal is an internal version of the Minor Alarm and does not supply any new information.

The individual error signal on test point TP106 could be monitored for rate to give an indication of overall bit error rate.

9. Descrambler Output

a. Electrical: This signal is called NRZ and is available at TP102 through 1000 ohms and at connector pin 10A of Receive Input Unit 4023. NRZ is available at connector pin 11A. The signals are TTL levels.

b. The NRZ signals are the output of the descrambler. This signal is sampled appropriately by the main and control frame circuitry to decode the multiplexed format.

The characteristics of this signal has little information concerning system performance. Signal activity is critically important to multiplexer operation.

10. Main Frame Bit Errors

a. Electrical: A TTL signal is available at IC 22A pin 5 on the Receive Time Base 4024. This signal is a logic 1 pulse when a main framing bit of the wrong polarity is received. This signal is active during the synchronization process.

The pulse duration is slightly less than one main frame period. Even with continuous incorrectly received main framing bits, the error signal will pulse for each error. The signal will go to logic 0 at the occurrence of the DIG 2 signal preceding the receipt of a framing bit. The error signal can be latched again at the end of the framing bit if it was in error.

This signal will have to be buffered and brought to a connector if it is to be used.

b. An indication of bit error rate could be obtained by measuring the rate of occurrences of main framing bit error signal.

However, error rate measurement would have to be disabled when the multiplexer was synchronizing.

11. Elastic Buffer Write Clocks (Receiver)

a. Electrical: These are TTL signals, one for each T1 channel, generated in the Receive Time Base 4024. They appear at the connect in the following order:

DIG 1	21A
DIG 2	21B
DIG 3	20A
DIG 4	20B
DIG 5	19A
DIG 6	19B
DIG 7	18A
DIG 8	18B
$\overline{\text{DIG 1}}$	TP102

b. These signals are used as clocks to the individual T1 elastic storage registers. As such they are important to multiplexer operation, however they do not have special system significance.

Due to the use of a ring counter to generate these signals, monitoring one of the signals is almost as useful as monitoring all.

12. Main Frame Timing

a. Electrical: $\overline{\text{DF}}$, $\overline{\text{PS}}$, $\overline{\text{P3}}$ are TTL signals that are generated in the Receive Time Base 4024. They are available at its connector as indicated below:

$\overline{\text{DF}}$	pin 14A
DF	16A and TP103
$\overline{\text{PS}}$	22A and TP101
$\overline{\text{P3}}$	22B

b. The $\overline{\text{DF}}$ pulse defines the position of the main framing bit, $\overline{\text{PS}}$ defines the position of control bits, and $\overline{\text{P3}}$ is used in generating DESTUFF TIME.

These signals are obviously important to multiplexer operation. However, they do not have special system significance. Activity of these signals could be monitored for fault isolation of main frame synchronization timing circuitry.

13. Control Frame Marker Errors

a. Electrical: A TTL flip flop on the Receive Control Channel Unit 4025 is latched to logic 1 when a marker code is received that contains an error. This signal remains a logic 1 for one control frame each error. It does not clear between successive errors.

This signal is available at IC-10B-9 or inverted at IC-10B-8. It is not available at a connector.

b. This signal could be monitored for rate. From this an indication of transmission error rate could be made.

This corresponds to monitoring six bits per control frame for errors. Monitoring the main framing bit gives the same function, but with 18 or 36 bits per control frame.

14. Stuff Code Error Monitor

a. Electrical: The stuff code status bits are available on the Receive Control Channel Unit 4025 at the appropriate times. The status thru-bits are available at IC-4A-5, IC-4B-9, and IC-SA-5, in parallel during the logic 1 pulse that occurs at IC-240-13. These signals are not available at the connector.

b. The status bits could be monitored for errors to give an indication of overall transmission error rate. This would provide 12 or 24 bits per control frame for error rate monitoring for the four and eight channel cases respectively. However, not all errors are detectable.

Implementation of this measurement would require the use of four signals that are not now available. Separate error detection hardware would be required because the multiplexer does not flag status codes that contain errors.

15. Destuff Rate

a. Electrical: A separate $\overline{\text{DSTF ENABLE}}$ TTL signal is generated for each TI channel in the Receive Control Channel Unit 4025. The signal can have a logic 0 pulse once each control frame, but only when the next stuff bit location for that TI channel contains a stuffed bit.

These signals are available at the connector of the Receive Control Channel Unit 4025 at the following pins:

$\overline{\text{DSTF ENABLE}}$	1	22A
	2	21A
	3	20A
	4	19A
	5	18A
	6	17A
	7	16A
	8	15A

b. Monitoring the rate of destuffing gives an indication of relative rates of the Tl channel compared to the multiplexer clock.

More direct measurements of clock rates are available.

16. Three Level Error Density

a. Electrical: Violations in the receipt of the three level response signal are detected by the multiplexer Receive Input Unit 4023. Each detected error causes a logic 1 pulse at TP106 for a duration of 1 bit time. Each time the error density exceeds 10^{-5} at connector pin 21A, a logic 1 is generated. This becomes a Minor Alarm.

b. This signal is an internal version of the Minor Alarm and supplies no new information. The individual error signal at TP106 could be monitored for an indication of overall bit error rate.

17. Destuff Timing

a. Electrical: The $\overline{\text{STUFF RESET}}$ and DSTF TIME signals are generated in the Receive Control Channel Unit 4025. The $\overline{\text{STUFF RESET}}$ pulse clears the latches for each TI channel that latch the $\overline{\text{DSTF ENABLE}}$ signal. The $\overline{\text{STUFF RESET}}$ signal is TTL and available at connector pin 8B.

The DSTF TIME signal defines the period of time when the stuff bit locations are being received. This TTL signal is available at TP102 and connector pin 8A of the Receive Control Channel Unit 4025.

b. These timing signals are important to proper multiplexer operation, but have no particular importance from the system aspect. Activity of these signals could be monitored.

18. Elastic Buffer Overflow/Underflow

a. Electrical: The read and write connectors that control the elastic buffer are each two flip flop counters. They count in the following order 00, 10, 01, 00, with IC-10A-5 and IC-10B-9 being the write flip flops respectively. The read flip flops are IC-9A-5 and IC-9B-9. These TTL signals are not available at the connector of the Receive Channel Unit 4120, where generated.

b. When a bit is not destuffed correctly, it is possible for the receive elastic buffer for that T1 channel to overflow or underflow. This could be detected by comparing the read and write counters for the register. These signals are not available at the connector. A special circuit would be required for each channel to monitor for this condition.

A mis-destuff will cause loss of bit integrity and loss of synchronization in the next lower multiplexer. Detection of a mis-destuff would indicate the cause of such a resynchronization, but the occurrence of the resynchronization would be detected in any case.

The T1-4000 contains a circuit called an overflow indicator. The output of the circuit is a front panel lamp that is latched when an overflow is detected.

The signal that triggers the latch is only a nanosecond duration and, therefore, is not appropriate for direct monitoring. This signal would have to be widened before use. Its source is IC-5B-4 on the Receive Channel Unit 4120.

The rate of overflow/underflow could be used to estimate the error rate of the carrier bit stream. More powerful techniques are available however.

19. T1 Bipolar Output

a. Electrical: The received T1 bipolar data is available differentially between connector pins 6A and 7A of the Receive Channel Unit 4120. This is a balanced signal, 100 ohms, ±3 volts.

The received data is also available at TP104 of the Receive Channel Unit 4120 in non-return to zero TTL format. This signal is not affected by SEND ALARM as is the output data of bipolar format.

The TTL signal at IC-5C-10 is the output data in NRZ format. This signal is forced to a logic 0 by SEND ALARM.

b. Because this signal interfaces two equipments, it is a prime candidate for monitoring at the receiving device. Signal activity and amplitude are possible parameters to measure.

Phase jitter on this signal is due primarily to destuffing and has no particular system significance.

The bit rate can be more easily monitored at the clock.

20. Tl Received Derived Clock

a. Electrical: The Tl channel derived clock is available at TP106 on the Receive Channel Unit 4120. It is not available at a connector pin.

The phase locked loop error signal is available at TP102 of the same unit.

b. Phase jitter on the clock is due primarily to destuffing. Therefore, it has no system significance except as a possible means of detecting incorrect destuffs. Interpretation of phase error for this purpose could be difficult.

The frequency and activity of the clock could be monitored to indicate the general health of the phase loop/crystal oscillator.

Candidate Monitor Points for Tl-4000 Transmitter

NOTE: A basic problem exists in monitoring any transmitter; it does not have quality indicators as does a receiver. That is, indicators such as eye pattern, three level violators, and loss of synchronization. Therefore, monitoring is limited to health indications such as activity or frequency unless a parallel operating transmitter is used for relative comparisons.

21. T1 Input Signals

a. Electrical: The T1 input signal is balanced, 100 ohms, bipolar, 50 percent duty cycle return to zero. The input pulses are ±3 volts.

   These signals are available at the individual Transmit Channel Unit 4110 connectors, pins 10A and 11A.

b. This is an interface signal having the possibility of being degraded in transmission between devices. As such, it could be monitored for bipolar violations, activity, signal level, or bit rate.

22. T1 Bipolar to Non-Return to Zero Converter

a. Electrical: The T1 data in TTL NRZ format is available at TP104 on the Transmit Channel Unit 4110 for each transmit T1 channel.

b. Activity of this signal (or lack of it) indicates functionality of the clock recovery tank circuit and the interface circuitry for the T1 signal. It has no special system significance.

23. T1 Rate Derived Clock (Transmitter)

a. Electrical: A bit rate clock is derived from each T1 input using an RLC parallel resonant tank circuit. The derived clock is available in TTL form at TP1-5 of the Transmit Channel Unit 4110.

b. Activity or frequency of this signal could be measured to determine proper operation of the circuitry and activity of the input data.

   Phase jitter of the data and clock signals could be measured.

24. Basic Transmitter Clock

a. Electrical: The clock is available in TTL form at TP106 of the Transmit Time Base Unit 4021.

b. The basic clock for the common equipment is generated on the Transmit Time Base Unit 4021 using a crystal oscillator.

25. Stuff Enable

a. Electrical: STUFF ENABLE, one signal for each T1 channel. Available at Transmit Control Channel Unit 4022 connector in TTL form.

CH1	22B	CH5	18B
CH2	21B	CH6	17B
CH3	20B	CH7	16B
CH4	19B	CH8	15B

b. A signal pulse signifies that one bit will be stuffed for its related T1 channel. The pulse will occur during a specific time slot when it does occur.

The rate of this signal is directly related to the stuff rate of the channel and the relative bit rates of the T1 channel and the transmit multiplexer output.

Activity on these signals is relatively independent channel to channel from an electrical viewpoint. Therefore, activity on the individual signals signifies proper operation of the stuff control function for the individual channels.

26. Elastic Buffer Read Clocks

a. Electrical: Each T1 channel has a separate DIG signal. These are TTL clock signals each having a different phase. They are available at the Transmit Time Base Unit 4021 connector.

DIG 1	21B	DIG 5	19B
DIG 2	21A	DIG 6	19A
DIG 3	20B	DIG 7	18B
DIG 4	20A	DIG 8	18A

b. This signal is the clock that reads the elastic buffers. Signals are generated in a ring counter and, therefore, are electrically dependent. Monitoring activity of DIG 1 is almost as significant as monitoring all the DIG signals.

27. Stuff Time

a. Electrical: This TTL clock defines the time during the control frame when bits are to be stuffed. It is generated in the Transmit Control Channel Unit 4022 and is available at TP102 and connector pin 8A of the unit.

b. Activity or frequency of this clock could be measured to determine proper operation of the control frame logic. This signal is generated by decode of the same counter that is decoded to clock the STUFF ENABLE signals.

28. Basic Clock for Control Frame Generator, $\overline{\text{CHAN CLK}}$

a. Electrical: $\overline{\text{CHAN CLK}}$ is a TTL signal generated in the Transmit Time Base Unit 4021. It is available at TP105 and connector pin 13B of the unit.

b. This signal is the basic clock for the control frame generator. Activity and frequency of this signal could be inferred by monitoring output signals of the control frame generator, such as STUFF TIME.

29. Transmit Bit Stream (TTL)

a. Electrical: The transmit serial bit stream is available in TTL form at the input to the partial response filter. That is, connector pins 7A and 7B of the Interface Unit 4090.

b. This signal could be monitored for activity since it is the final output of the logic portion of the multiplexer.

However, if measurements are made on the analog output of the transmitter, this signal will supply little additional system information.

30. Analog Transmit Signal

a. Electrical: The output signal is 75 ohms single ended, available at the Interface Unit 4090 connector pins 16A and 16B. It is also available at TP103 on the Interface Unit.

b. This signal potentially has significance because it is an interface signal. However, its characteristics are much less significant than similar characteristics of the receiver input signal due to the fact it is directly at the source output.

Signal level could be measured to indicate the health of the partial response filter and output amplifier as well as to indicate activity.

Candidate Monitor Points for T1-4000 Multiplexer; Power and Alarm Unit SD-4010-02

31. DC Voltages

a. Electrical: Four DC voltages are supplied. These are available at the Power and Alarm Unit 4010-02 connector as indicated below:

+20 Vdc unregulated	TP105 1A 1B
+12 Vdc regulated	TP104 2A 2B 3A 3B
+ 5 Vdc regulated	TP103 6A 6B 7A 7B
- 6 Vdc regulated	TP102 4A 4B 5A 5B
Ground	TP101 (no isolating resistor) 8A 8B 9A 9B

The primary power source is either -24 or -48 volts DC. The primary power is available at connector pins 22A and 22B; ground at 21A and 21B.

b. The voltage level of these supplies could provide an early warning of impending failure due to a drooping supply.

32. Loop Alarm

a. Electrical: This signal is available at the Power and Alarm Unit 4010 connector pin 13A.

b. Open circuit indicates that the multiplexer transmitter is looped back to the receiver.

33. Fuse Alarm

a. Electrical: The fuse alarm signal is not available at the Power and Alarm Unit 4010 connector. An on/off alarm signal is available internally to the power unit.

b. This signal indicates a blown fuse at the primary input.

34. Minor Alarm/Three Level Error Density

a. Electrical: This signal is available at the Power and Alarm Unit 4010 connector pin 14A. Minor Alarm is a relay closure activated by Three Level Error Density signal. This signal is available at the Power and Alarm Unit 4010 connector, pins 20A and 19A.

b. An alarm indicates detected three level partial response violations at a rate of 10^{-5}.

35. Main Reframe

a. Electrical: This signal is approximately 5 volts during reframe and zero volts when main frame is synchronized.

It is available at the Power and Alarm Unit 4010 connector pin 7A. The source of the signal is Receive Time Base 4024 connector pin 13A.

b. This signal indicates that normal data transmission has been interrupted due to lack of main frame synchronization.

The rate at which this occurs is trendable and gives an indication of the bit error rate, general health of communication, and health of the transmit and receive main framing circuitry.

36. Sub-Reframe (Control Reframe)

a. Electrical: This TTL signal is available at the Power and Alarm Unit connector pin 8A and at the Receive Control Channel Unit connector pin 6B. Logic 1 indicates lack of control frame synchronization.

b. This signal indicates that normal data transmission has been interrupted due to lack of control frame synchronization. Loss of main frame synchronization will probably cause loss of control frame synchronization.

The rate of which Sub-Reframe occurs is trendable and gives an indication of the bit error rate, general health of communications, and health of the transmit and receive control frame circuitry.

37. Send Alarm (Multiplexer)

a. Electrical: This TTL signal is available at the Power and Alarm Unit 4010 connector pin 6A.

b. Send Alarm becomes a logic 1 when there is a loop Alarm or when Main Reframe or Sub-Reframe persist for more than 250 milliseconds.

Send Alarm is not latched, therefore, it becomes a logic 0 following removal of the cause.

This signal indicates inoperability of the receiver and is, therefore, important for alarm reporting.

38. Remote Alarm

a. Electrical: This TTL signal is available at the Receive Control Channel Unit 4025 connector pin 12A and Power and Alarm Unit 4010 connector pin 9A.

b. This signal indicates receipt of a Send Alarm from the remote transmitter.

This signal is used in control of the auto-switchover sequence.

39. Major Alarm (Multiplexer)

a. Electrical: Contact closure of a relay indicates a Major Alarm. Two contacts are available at the Power

and Alarm Unit 4010 connector; pins 15A and 16A for one set of contacts and pins 17A and 18A for the other set.

b. A Major Alarm is given when a Send or Loop Alarm exists or when Remote Alarm is received.

This is obviously an important indication, but need not be monitored if the sources of the alarm are monitored.

Candidate Monitor Points for VICOM T1-4000 Protection Switch

40. Major Alarm

a. Electrical: This signal is from the protection switch and is not the same as the multiplexer Major Alarm.

b. Major Alarm is given under any of the following conditions:

- Transfer attempt failed.
- Standby multiplexer has Local Alarm while transferred.
- Remote Alarm received.
- Switch unit or standby transmit multiplexer power failure.

41. Minor Alarm

a. Electrical: This signal is from the Protection Switch and is not the same as the multiplexer Minor Alarm.

b. Minor Alarm is given under any of the following conditions:

- Receiver transferred.
- Receiver or transmitter automatic transfer disabled.
- Transmit side transferred.
- Switch unit loses power.
- Standby multiplexer is in Local Alarm.

42. DC Power

a. Electrical: DC power for the protection switch is supplied by the standby multiplexer. In addition +12 Vdc is also supplied by the primary multiplexer.

b. Monitoring these voltages in the protection switch, in addition to monitoring in the multiplexers, would only confirm the cable connection.

43./44. Send Alarm/Remote Alarm

a. Electrical: Send Alarm is controlled by the protective switch to implement the switchover sequence.

b. The switchover is accomplished by the following sequence. All alarms in the sequence are candidates for monitoring.

1) When a receiver loses main or control frame synchronization for more than 20 milliseconds, the protective switch transfers operation to the standby receiver. The standby receiver attempts to synchronize for 4.4 seconds. When synchronization is achieved, the transfer is latched and a Minor Alarm is generated. The transfer can only be reset by manual or external logic command.

2) In the event the standby receiver could not synchronize, the normal receiver is switched back into operation, a send alarm is transmitted and a 60 second delay is initiated. Also Major and Minor Alarms are generated. When the send alarm is detected as remote alarm at the remote receiver for more than one second, the standby transmitter is transferred to operation, a five second delay is initiated and Major and Minor Alarms are generated at that site.

3) The local, normal receiver now attempts to synchronize to the remote standby transmitter. When synchronization is acquired within five seconds, the send alarm and local minor alarm ends. The remote alarm at the remote receiver, therefore, ends. This latches the remote standby transmitter into operation. The remote major alarm ends.

4) When the local normal receiver has not acquired synchronization to the remote standby transmitter within five seconds, the remote standby transmitter is

transferred to off line and the normal transmitter is put back in operation.

5) At this point the standby receiver and standby transmitter have been used in unsuccessful attempts to acquire synchronization, and the normal hardware is on line. The normal receiver continues to attempt to acquire synchronization for the remainder of the 60 second delay that was started at the local site when the normal receiver was put back on line. If the receiver does acquire synchronization, the send alarm ends, as well as local and remote Major and Minor Alarms. The system returns to normal operation.

6) If the normal receiver does not synchronize during this 60 second period, the local protection switch will reset ending the send alarm, local and remote major and minor office alarms. A new transfer will then be attempted with the above sequence repeating itself until synchronization is acquired.

7) A special mode of operation exists when the operating multiplexer is placed in the loop mode. In this case, the protection switch causes send alarm to be transmitted for 0.5 second followed by 0.5 second of no alarm ad infinitum. This modified send alarm inhibits transfer of the transmit multiplexer at the remote site.

45.-48. Tx/Rx Transfer Status/Latch

a. Electrical: The following status information can be made available:

Receiver transferred to standby.

- Temporary
- Latched

Transmitter transferred to standby.

- Temporary
- Latched

b. When a switchover cannot be found that solves the anomaly, the process continues to recycle and the Major and Minor Alarms are cleared and recycled. This condition will have to be recognized as a down link.

A4-4 T1-4000 ALARM AND PARAMETER ANALYSIS DATA

T1-4000 Receiver

1. Three Level Partial Response Input

Usefulness

PA/TA-2
Limited usefulness since must be processed by 1/2 PR filter and multiplexer AGC before representing final data signal.

FI-4
Of use since activity verifies radio output signal is active, as well as demonstrates continuity of analog signal from radio to multiplexer.

Availability -3

Available on connector pin J37 (coaxial cable).

Processing -1

Requires analog filtering, AGC, eye pattern monitoring, and software interpretation of results of all information to be extracted. (At a minimum, processing degenerates to analog activity detection unit.)

2. Three Level Partial Response After Filtering

Usefulness

PA/TA-2
Limited usefulness since it must be processed by multiplexer AGC before representing final data signal.

FI-1
Is not required to fault isolate to multiplexer input section since same signal after AGC is available to show fault in analog input circuitry.

Availability -1

Available on board at SD4090; IC1-1.

Processing -1

Requires AGC and eye pattern monitor in addition to software.

3. Three Level Partial Response After AGC

Usefulness

PA/TA-4
Eye pattern may be monitored for predictive degradation or presumptive error rate due to degradation of multiplexer analog circuitry, radio path distrubance or radio degradation.

FI-4
Through use of proper eye pattern monitor and software processing, degradation due to hardware or radio path may be distinguished.

Availability -1

Available on board at SD4090; R33.

Processing -2

Requires eye pattern monitor and software interpretation of results, but does not require extensive analog filtering or AGC.

4. AGC Control Signal

Usefulness

PA/TA-2
Could be employed to monitor analog level of radio output. Since with FM receivers the baseband output does not vary significantly over all ranges of expected RF input level, including deep fades, this parameter is only of marginal utility in performance assessment.

FI-2
Only marginally useful for fault isolation due to availability of three level signal after AGC.

Availability -1

Available on board at SD4090; emitter of Q12.

Processing -3

Only special software processing to correlate this voltage with radio link perturbations and trend would be required.

5. <u>High and Low Slicer Outputs</u>

PA/TA-2

FI-2
Very limited usefulness due to availability of three level partial response signal which is the same signal before digital processing.

<u>Availability -2</u>

Available on connector pins J5-21A and J5-20A.

<u>Processing -2</u>

At a minimum, would require hardware processing to encode or reformat slicer output into form suitable for transmission to monitor system.

6. <u>Derived Clock (Receiver Input)</u>

<u>Usefulness</u>

PA/TA-1
Presence of clock used to sample the slicer output signals is not applicable to performance assessment. Its main significance is internal to the equipment and not at system level.

FI-2
Of some FI usefulness since absence of clock would indicate failure of clock recovery circuitry.

<u>Availability -2</u>

Available on connector pin J6-8A.

<u>Processing -2</u>

Would require digital signal activity indicator to yield binary active/inactive output to monitor system.

7. <u>Phase Error for Derived Clock (Receiver Input)</u>

<u>Usefulness</u>

PA/TA-2
Suitable processing could yield phase jitter of recovered clock which has very limited PA usefulness because of the

difficulty in correlating jitter with bit error rate. Also, more comprehensive monitors are available, such as eye dispersion.

FI-2
Of very limited usefulness since many other parameters may be monitored to indicate failure of clock recovery circuit such as loss of main frame synchronization. Also is not required to fault isolate on the equipment level.

Availability -1

Available on board at SD4023; R37.

Processing -2

Would require analog filtering at a minimum to put in a form suitable for input to monitoring system.

8. Three Level Violation Detector

Usefulness

PA/TA-4
Very useful as it may be employed to produce a presumptive error rate for the T1-4000 analog and radio link. Usefulness is enhanced by the fact that this operation is performed digitally after the data is sampled and quantitized.

FI-3
While not necessary to fault isolate to the equipment level, this signal when employed jointly with other signals such as main reframe alarm, may be used to fault isolate to the subsystem level. This signal is directly related to the error rate of the signal upon which framing is attempted by the multiplex receiver.

Availability -1

Available on board at SD4023; R40.

Processing -2

Hardware processing in the form of a counter or integrator is postulated.

9. Descrambler Output

Usefulness

PA/TA-1
The digital descrambled data is of no use in performance assessment because its main significance is internal to the equipment and not at system level.

FI-1
The internal data activity or sequence is not required nor is it useful in fault isolation. Its main significance is internal to the equipment and not at system level.

Availability -2

Available on connector pin J6-10A.

Processing -2

Hardware processing in the form of a digital data activity indicator would be required.

10. Main Frame Bit Errors

Usefulness

PA/TA-4
While occurring at a much lower rate than the multiplexer input data rate, this gives a sampled or lower rate version of the actual digital data error rate. This is one of the few signals which gives a version of the actual data error rate without the use of an external probe signal. Note processing of the three level partial response signal gives only a presumptive indication of the error rate internal to the multiplexer and is based upon the assumption of perfect or known alignment of the multiplexer detection circuit and the three level partial response detection circuit.

FI-3
While not absolutely necessary for fault isolation to the equipment level, this parameter's ability to indicate the range of the system bit error rate makes it extremely useful to confirm system faults or even contribute to the location of faults within the system.

Availability -1

Available on board at SD4024; I22A-5.

Processing -2

Hardware processing in the form of a counter or integrator would be required. Further processing of the refined data can be accomplished with existing ATEC software.

11. Elastic Buffer Write Clocks (Receiver)

Usefulness

PA/TA-1
This signal is related to the internal timing of the multiplexer and processing of this signal to extract performance related information is not possible.

FI-2
Monitoring of this signal would only indicate the general health of a portion of the multiplexer receiver timing circuitry. The signal has no system significance.

Availability -2

Available on connector pins J7-18A, J7-18B, J7-19A, J7-19B, J7-20A, J7-20B, J7-21A, and J7-21B.

Processing -2

Hardware processing, at least in the form of a digital signal activity indicator, would be required.

12. Main Frame Timing

Usefulness

PA/TA-1
Relative occurrence of the main frame timing bit is not useful for performance assessment. Its main significance is internal to the equipment and not at system level.

FI-2
Occurrence of this signal only indicates the relative time location of the main frame bit and has limited significance for fault isolation.

Availability -2

Available on connector pin J7-16A.

Processing -2

Hardware processing in the form of an activity indicator would be required.

13. Control Frame Marker Errors

Usefulness

PA/TA-2
This signal becomes a 1 and remains a 1 for the duration of the control frame if an error is detected in the marker code. Consequently, it only indicates the presence of one or more errors in the marker code and is only limited usefulness with respect to performance assessment.

FI-2
Does not contribute to fault isolation to the equipment level and, hence, is only of very limited usefulness. Other, more comprehensive, indicators are available, such as main frame errors.

Availability -1

Available on board at SD4025; IC10B-9.

Processing -2

Hardware processing in the form of a counter would be required.

14. Stuff Code Error Monitor

Usefulness

PA/TA-2
Monitoring this parameter corresponds to monitoring six bits per control frame for errors while monitoring the main framing bit provides a similar function at a higher rate of 18 or 36 bits per control frame. Additionally, since there are three stuff bits which are compared for an error, only the occurrence of one or three errors out of the three bits may be detected. Vary limited usefulness compared to use of main framing bit.

FI-2
Does not contribute to fault isolation to the equipment level and, in general, only of very limited usefulness. Other, more comprehensive, indicators are available, such as main frame errors.

Availability -1

Available on board at SD4025; IC4A-5, IC4B-9, IC5A-5, and IC240-13.

Processing -2

Hardware processing in the form of a counter would be required.

15. Destuff Rate

Usefulness

PA/TA-2, FI-2
The relative destuff rate gives an indication of the relative difference between the multiplexer clock and the T1 channel clock. This clock rate difference is of little significance, therefore, the destuff rate has limited usefulness for either performance assessment or fault isolation.

Availability -2

Available on connector pins J8-15, J8-16A, J8-17A, J8-18A, J8-19A, J8-20A, J8-21A, and J8-22A.

Processing -2

A counter or possibly a frequency converter would be required to extract information for subsequent processing.

16. Three Level Error Density

Usefulness

PA/TA-3
The three level violation signal is internally processed to yield this signal which becomes a logic 1 when detected violation rate exceeds 10^{-5}. Consequently, while useful, it is not as useful as the three level violation detector signal itself.

FI-2
Does not assist in fault isolating to the system level and, generally contributes little information useful for fault isolation because other, more comprehensive, indicators are available, such as main frame errors.

Availability -2

Available on connector pin J6-21A.

Processing -2

Hardware processing in the form of a very simple counter would be required.

17. Destuff Timing

Usefulness

PA/TA-1
This signal defines the particular time when the destuff signals for a particular channel are being received and have no impact upon system performance assessment. Its main significance is internal to the equipment and not at system level.

FI-2
Not required to fault isolate to the equipment level and, generally, of very limited usefulness because its main significance is internal to the equipment and not at system level.

Availability -2

Available on connector pins J8-8A and J8-8B.

Processing -2

A digital signal activity indicator would be required.

18. Elastic Buffer Overflow/Underflow

Usefulness

PA/TA-2
Overflow/underflow of the elastic buffers will usually be due to bit errors. These errors are more directly monitored or estimated by numerous other approaches, such as collecting main frame errors.

FI-3
Buffer overflow or underflow will cause loss at bit integrity and subsequent resynchronization of lower level multiplexers or encryption devices. Consequently, in order to distinguish between faults in the lower level devices and the occurrence of bit errors in the T1-4000 and radio path, this parameter has a useful application to fault isolation. Certainly, this parameter is not in the required category.

Availability -1

Available on board at SD4120; IC19-3.

Processing -2

Hardware processing in the form of a digital event counter is postulated.

19. T1 Bipolar Output

Usefulness

PA/TA-1
Presence or absence of a bipolar output signal (containing data which is not known) is of no use in performance assessment.

FI-3
Absence of an equipment output signal is a generally, highly useful quantity of information which applies to system fault isolation. It may be easily argued that this parameter be rated with a value of 4.

Availability -3

Available on connector pins J15-6A and 7A, J18-6A and 7A, J21-6A and 7A, J24-6A and 7A, J27-6A and 7A, J30-6A and 7A, J33-6A and 7A, and J36-6A and 7A.

Processing -2

A digital data activity indicator would be required.

20. T1 Received Derived Clock

Usefulness

PA/TA-1
Presence or absence of a clock signal is not useful in the

area of performance assessment because its main significance is internal to the equipment and not at system level.

FI-2
This parameter does not assist in equipment level fault isolation and is only of limited usefulness. Other, more comprehensive, indicators are available, such as loss of T1WB1 synchronization.

Availability -1

Available on board at SD4120; R37.

Processing -2

A digital data activity indicator would be required.

T1-4000 Transmitter

21. T1 Input Signals

Usefulness

PA/TA-1
Input signals are not useful for performance assessment unless their data pattern is known.

FI-3
Presence or absence of equipment input and output signals are useful in fault isolating to the equipment level.

Availability -3

Available on connector pins J13-10A and 11A, J16-10A and 11A, J19-10A and 11A, J22-10A and 11A, J25-10A and 11A, J28-10A and 11A, J31-10A and 11A, and J34-10A and 11A.

NOTE: There are eight T1 input signals.

Processing -2

A digital activity indicator would be required.

22. T1 Bipolar NRZ Converter

Usefulness

PA/TA-1
This is the TTL version of the input signal and is not useful

for performance assessment. Its main significance is internal to the equipment and not at system level.

FI-2
This is only of very limited usefulness in fault isolation because its main significance is internal to the equipment and not at system level.

Availability -1

Available on board at SD223; DS106.

Processing -2

A digital data activity indicator would be required.

23. Tl Rate Derived Clock (Transmitter)

Usefulness

PA/TA-2
This signal could be monitored to yield information concerning phase jitter on the data and on the recovered clock. Such information is only of limited usefulness with respect to performance assessment because significant jitter is expected as normal.

FI-2
Does not meaningfully assist in equipment level fault isolation because more comprehensive indicators are available, such as loss of TlWBl synchronization.

Availability -1

Available on board at SD4110; R13.

Processing -2

A digital signal activity indicator would be required.

24. Basic Transmitter Clock

Usefulness

PA/TA-1
Presence or absence of clock does not relate to performance assessment or trending because its main significance is internal to the equipment and not at system level.

FI-3
This was subjectively given a value of three rather than a value of 2 since it represents the main clock signal which is used throughout the multiplexer.

Availability -1

Available on board at SD4021; R12.

Processing -2

A digital signal activity indicator would be required.

25. Stuff Enable

Usefulness

PA/TA-1
Stuff enable signals are not expected to have any relevant information for performance assessment. The stuff enable signals vary over a small relative range and the variation is only due to minute frequency differences between the T1 clock and the T1-4000 clock.

FI-2
The main significance of this signal is internal to the equipment and not at system level. In addition, failure of these circuits could be detected using more comprehensive indicators, such as elastic buffer overflow in the T1-4000 receiver.

Availability -2

Available on connector pins J4-15B, J4-16B, J4-17B, J4-18B, J4-19B, J4-20B, J4-21B, and J4-22B.

Processing -2

A digital signal activity indicator, a counter or frequency to digital converter would be required.

26. Elastic Buffer Read Clocks

Usefulness

PA/TA-1
This internal signal has no application to performance assessment or trending because its main significance is internal to the equipment and not at system level.

FI-2
This is an internal signal which does not assist meaningfully in fault isolation because its main significance is internal to the equipment and not at system level.

Availability -2

Available on connector pins J3-18A, J3-18B, J3-19A, J3-19B, J3-20A, J3-20B, J3-21A, and J3-21B.

Processing -2

A digital signal activity indicator would be required.

27. Stuff Time

Usefulness

PA/TA-1
Knowledge of the time segment of the control frame in which bits are stuffed does not relate to performance assessment or trending because its main significance is internal to the equipment and not at system level.

FI-2
This parameter does not simplify or ease the problem of equipment level fault isolation because it does not have system level significance.

Availability -2

Available on connector pin J4-8A.

Processing -2

A digital signal activity indicator would be required.

28. Channel Clock, $\overline{\text{CHAN CLK}}$

Usefulness

PA/TA-1
This internal timing signal is not useful for performance assessment because its main significance is internal to the equipment and not at system level.

FI-2
Being an internal clock signal, this parameter does not contribute significantly to equipment level fault isolation

because it does not have system level significance.

Availability -2

Available on connector pin J3-13B.

Processing -2

A digital signal activity indicator would be required to interface this parameter with the ATEC based monitoring system.

29. Transmit Bit Stream (TTL)

Usefulness

PA/TA-1
Unless the data sequence is known, by means of a probe pseudorandom sequence for example, data stream activity or data sequence is not related to performance assessment. Moreover, this represents the composite multiplexer transmitter data output.

FI-2
This internal signal is relatively useless for fault isolation, especially in relation to the composite analog transmitter output signal, because its main significance is internal to the equipment and not at system level.

Availability -2

Available on connector pins J5-7A and J5-7B.

Processing -2

A digital signal activity indicator would be required.

30. Analog Transmit Signal

Usefulness

PA/TA-4
This is given a rating of four for performance assessment where it is assumed that if an eye pattern monitor is employed at the receiver, a similar monitor with adequate spectral shaping should be placed at the transmitter. The transmitter eye monitor would serve as a reference or standard for the receiver eye pattern monitor. Without

the transmitter eye pattern reference, the receiver eye pattern results are highly presumptive.

FI-3
Knowledge that the analog output of the multiplex transmitter is active is very valuable for fault isolation on the multiplexer transmitter, radio transmitter and receiver, and multiplexer receiver link.

Availability -3

Available on connector pins J5-16A and J5-16B.

NOTE: This signal is a normal multiplexer transmitter output.

Processing -1 (originally a value of 2)

Both hardware and specialized software would be required to fully exploit the performance assessment properties of this parameter. The rating has been reduced from two to one since a one-half partial response filter and AGC would be required in addition to the normal eye pattern monitor hardware.

T1-4000 Power and Alarm Unit

31. DC Voltages

Usefulness

PA/TA-3
Power supply voltages are useful to monitor gradual supply degradations in order to permit maintenance prior to supply failure. Voltage deviation from nominal and the rate of change of the deviation are both important contributors to performance margin.

FI-4
Since a major source of equipment failure arises due to power supply failure, knowledge of the general state of the output power supply voltages is extremely important with respect to fault isolation.

Availability -3

Available on connector pins J12-1A, J12-2A, J12-4A, J12-6A, J12-8A, J12-21A, and J12-22A.

Processing -4

Voltages can be measured by a MAC with only software processing required.

32. Loop Alarm

Usefulness

PA/TA-1
The looped condition of a multiplexer is irrelevant to performance assessment because it does not contain performance information.

FI-4
Knowledge that a high level multiplexer is in a loop back configuration is essential to system fault isolation to the equipment level. It is postulated that a looped condition may only be detectable by a loop alarm (excluding the use of probe signals).

Availability -2

Available on connector pin J9-13A.

Processing -4

As this is a binary or "state" alarm, no special processing is necessary.

33. Fuse Alarm

Usefulness

PA/TA-1
Not relevant to performance assessment because this alarm indicates complete loss of the equipment, a condition not requiring interpretation or assessment.

FI-4
Very important for rapid fault isolation at the system level because this alarm indicates complete loss of the equipment.

Availability -1

Available on board at SD4010; cathode of CR104.

Processing -4

After buffering as dictated by the availability rating, no further special processing is required.

34. Minor Alarm/Three Level Error Density

Usefulness

PA/TA-4
This alarm is activated when the partial response, three level violation rate exceeds 10^{-5} and is extremely useful for performance assessment as related to the composite link formed by the high level multiplexers, the radio system, and RF channel.

FI-3
While not necessary for fault isolation, the occurrence of this alarm directly relates to the occurrence of failure related alarms at lower level multiplexers in the system and hence provides significant information.

Availability -2

Available on connector pin J9-14A.

Processing -2

Hardware processing in the form of a counter would be required in order to integrate the events into a number which may be read by the monitoring system.

35. Main Frame

Usefulness

PA/TA-4, FI-4
This alarm indicates that the normal data stream has been interrupted due to lack of main frame synchronization. The relative number of reframes per unit time is a measure of the throughput of the high level multiplexer and radio portion of the system. Performance assessment is concerned with the frequency of this alarm while fault isolation is simply related to the presence of this alarm.

Availability -2

Available on connector pin J9-7A.

Processing -2

To qualify for performance assessment usage, some type of counter would be required to monitor this alarm between monitor system scans.

36. Control Reframe

Usefulness

PA/TA-3, FI-3
Valuable at the system level for both performance assessment and fault isolation because it indicates loss of the multiplexer function and/or degraded channel error rate. This alarm is more sensitive to channel errors than frame alarm.

Availability -2

Available on connector pin J9-8A.

Processing -2

To qualify for performance assessment usage, some type of counter would be required to monitor this alarm between monitoring system scans.

37. Send Alarm (Multiplexer)

Usefulness

PA/TA-2
This alarm indicates that a loop alarm exists or that main reframe or sub-reframe has persisted for more than 250 ms. While this alarm indicates inoperability of the receiver, it is only of marginal value to performance assessment since the basic cause of this alarm cannot be known with certainty.

FI-4
As this alarm indicates inoperability of the receiver, it is important for system fault isolation.

Availability -2

Available on connector pin J9-6A.

Processing -4

No special hardware or software processing would be required.

38. Remote Alarm

Usefulness

PA/TA-2
This alarm is only of negligible value for performance assessment due to the reasons presented under send alarm.

FI-2
This alarm is of negligible value for fault isolation since the local alarm on the conjugate equipment conveys the same information.

Availability -2

Available on connector pin J9-9A.

Processing -4

No special hardware or software processing would be required.

39. Major Alarm (Multiplexer)

Usefulness

PA/TA-3
Major alarm is important to performance assessment as it indicates the status of the back up or redundant multiplexer in addition to the active multiplexer. Note that there is one of the above major alarms for each of the two T1-4000 redundant receivers and consequently a major alarm on the standby receiver implies that the system performance margin is low as receiver back up is unavailable.

FI-4
This alarm is important for fault isolation since it implies that either a 20 volt supply is defective, a remote alarm has been received or that the receiver cannot maintain or control frame synchronization.

Availability -4

Available on connector pins J9-15A and J9-16A.

Processing -4

No special hardware or software processing would be required.

T1-4000 Protection Switch

40. Major Alarm (Protection Switch)

Usefulness

PA/TA-2
This alarm is related to the switchover characteristics of the two multiplexer receiver and is only of marginal performance assessment usefulness because it does not contain significant information pertinent to assessment of performance margin.

FI-4
Major alarm is given if a transfer attempt has failed, the standby multiplexer has local alarm while transferred, a remote alarm has been received or a power failure has occurred in the switch unit or standby multiplexer transmitter. Its usefulness to fault isolation is obvious.

Availability -4

Available on connector pins J5-7A and J5-7B.

Processing -4

No special processing required.

41. Minor Alarm (Protection Switch)

Usefulness

PA/TA-2
This alarm is related to the switchover characteristics of the protection switch and standby multiplexer and is not directly applicable to performance assessment because it does not contain significant information pertinent to assessment of performance margin.

FI-3
Minor alarm is given if a receiver transferred, a receiver or transmitter automatic transfer has been disabled, a transmitter transferred, a switch unit loses power or a standby multiplexer is in local alarm. It is not as

important to fault isolation as a major alarm.

Availability -4

Available on connector pins J5-8A and J5-8B.

Processing -4

No special processing required.

42. DC Power

Usefulness

PA/TA-3
This power is supplied by the standby multiplexer and indicates standby multiplexer power supply performance margin.

FI-4
May be used to confirm fault in standby multiplexer power supply.

Availability -3

Available on connector pins J5-2B, J5-4B, and J5-1A.

Processing -4

No special processing required.

43. Send Alarm (Protection Switch)

Usefulness

PA/TA-3
This alarm indicates the transfer status of the redundant transmitters and receivers. It is useful since it indicates the back up or redundancy capability of the system and its activity may be employed to monitor the general automatic switchover activity within the redundant equipment.

FI-4
This alarm is important to fault isolate within the redundant transmitter and receiver pairs.

Availability -2

Available on connector pin J5-20B.

Processing -4

No special processing required.

44. Remote Alarm (Protection Switch)

Usefulness

PA/TA-2
Should be rated one if corresponding send alarm is assumed available, potential unavailability due to telemetry system failure warrants a value of two.

FI-2
Should be rated one if corresponding send alarm is assumed available potential unavailability due to telemetry system failures warrants a value of two.

Availability -2

Available on connector pin J6-17B.

Processing -4

No special processing required.

45. Transmitter Transfer Status

Usefulness

PA/TA-3
TTL signal that actuates transfer from prime transmitter to standby unit. The fact that a switchover is attempted has significant impact upon the performance margin of the system since the switchover was caused wither by a temporary disturbance or equipment failure. This condition is of greater significance than somewhat useful and warrants a rating of three.

FI-4
With respect to fault isolation the transfer attempt condition is extremely important since a highly likely cause of this condition is failure of a multiplexer transmitter or receiver.

Availability -2

Available on connector pin J5-15B.

Processing -4

No special hardware or software processing would be required.

46. Transmitter Transfer Latched

Usefulness

PA/TA-3
The fact that a transfer from active to standby was attempted and successful is important since a probable cause of this condition is component failure in which case the system performance margin would be reduced to lack of a good standby unit.

FI-3
A rating of three is appropriate for fault isolation since the transfer status was rated four previously. Given that a transfer command is activated for a time period adequate to latch, it is not absolutely necessary to know that the standby latched; hence a rating of three rather than four.

Availability -1

Available on board at SD4033; IC2D13.

Processing -4

No special hardware or software processing required.

47. Receiver Transfer Status

Usefulness

PA/TA-3
TTL signal that actuates transfer from prime receiver to standby unit. The fact that a switchover is attempted has significant impact upon the performance margin of the system since the switchover was caused either by a temporary disturbance or equipment failure. This condition is of greater significance than somewhat useful and warrants a rating of three.

FI-4
With respect to fault isolation the transfer attempt condition is extremely important since a highly likely cause of this condition is failure of a multiplexer transmitter or receiver.

Availability -2

Available on connector pin J6-6A.

Processing -4

No special hardware or software processing would be required.

48. Receiver Transfer Latched

Usefulness

PA/TA-3
The fact that a transfer from active to standby was attempted and successful is important since a probable cause of this condition is component failure. In this case the system performance margin would be reduced due to lack of a good standby unit.

FI-3
A rating of three is appropriate for fault isolation since the transfer status was rated four previously. Given that a transfer command is activated for a time period adequate to latch, it is not absolutely necessary to know that the standby latched; hence a rating of three rather than four.

Availability -1

Available on board at SD4034; IC5A-1.

Processing -4

No special hardware or software processing would be required.

Appendix A5

AN/FRC-162(V) LOS FM RADIO

A5-1 AN/FRC-162 OPERATIONAL DESCRIPTION

A5-1.1 Transmitter Description

The following discussion refers to one of the transmitters. The operation of the other transmitter is identical. Figure A5-1 is a block diagram of the radio transmitter. There are three types of input signals shown. They are: (1) the transmit baseband which is a Partial Response signal at data rates up to 12.6 megabits, (2) the voice order wire (VOW) which covers from 300 Hz to 3000 Hz, and (3) the supervisory order wire which covers from 4 kHz to 8 kHz. The VOW and the supervisory order wire are combined within the audio channel unit into a 300 Hz to 8 kHz service channel which is coupled to an FM modulator where it modulates an 8.1 MHz subcarrier. The transmit baseband passes through a bandstop filter which eliminates spectral components from 8.0 MHz to 8.5 MHz, thereby conditioning the transmit baseband to accept a radio pilot at 8.5 MHz and the service channel at 8.1 MHz. After pilot insertion at 8.5 MHz, the baseband is coupled to the modulation amplifier where the 8.1 MHz service channel subcarrier is added.

The output signal from the modulation amplifier is coupled to the basic oscillator module which is the primary frequency determining element for the transmitter output. The oscillator frequency may be set between 1.78 gHz and 2.10 gHz depending on the final output frequency required. The oscillator is frequency modulated by the composite baseband signal. The modulated intermediate carrier from the basic oscillator is coupled through a 20 db load isolator to a 2 gHz amplifier. The load isolator isolates the basic oscillator from the 2 gHz amplifier so that the oscillator has an invariant load impedance. Isolator attentuation in the transmit direction is 0.5 db while attenuation of any reflected signal is 20 db. The 2 gHz amplifier raises the intermediate carrier signal level from 500 milliwatts to 5 watts. The amplified signal passes through a test coupler and 20 db load isolator to the first of two frequency doubler circuits.

A portion of the signal is sampled at the test coupler and routed to the AFC reference unit where it is mixed with a stable frequency generated by the AFC reference unit to produce a frequency exactly 70 MHz below the required intermediate carrier frequency. The 70 MHz difference signal is coupled to the AFC unit where it is frequency divided to approximately 16.7 Hz. A stable crystal controlled oscillator reference signal generated in the AFC unit is divided to 16.6893 Hz. The two signals are phase compared and any phase difference produces a dc correction voltage that is used to control the center frequency of the basic oscillator. This AFC function controls the transmit output frequency to within 0.0005 percent of the assigned frequency.

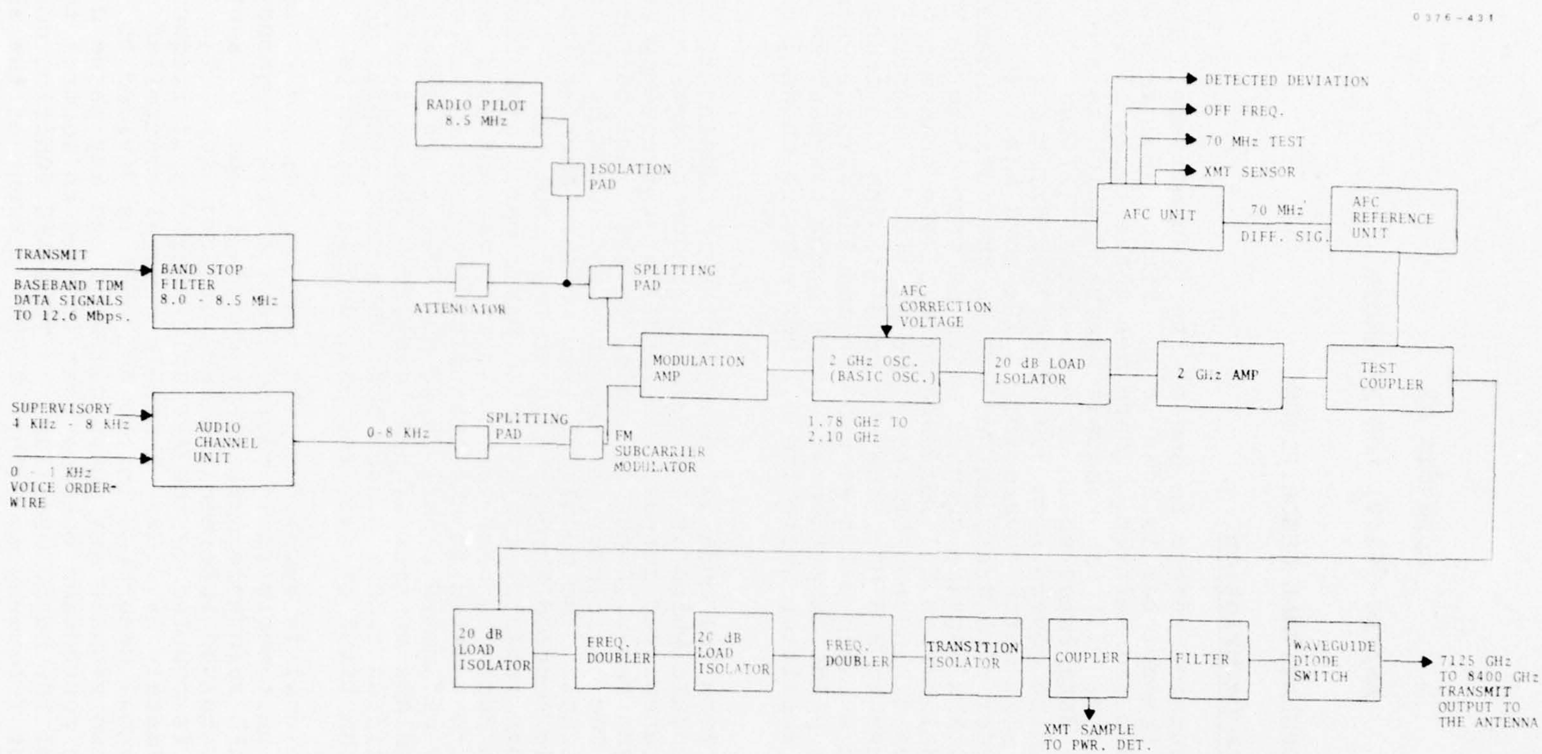


FIGURE A5-1. RADIO TRANSMITTER BLOCK DIAGRAM

The performance assessment related signal status shown coming from the AFC unit is a by-product of the basic AFC control. The 20 db load isolator is similar to the load isolator already described and is used to attenuate any reflected signal that might otherwise be coupled to the AFC circuits.

Two frequency doublers coupled through a 20 db load isolator are used to generate the final output carrier from the basic oscillator signal. A transition isolator provides 20 db isolation between the frequency doubler and the output waveguide filter, and provides a coax-to-waveguide transition. A waveguide coupler provides a sample of the transmit signal for monitoring of the output power by a subsystem control unit (not shown in the block diagram). The waveguide filter prevents signal radiation at unwanted frequencies. It is a 3-cell cavity which is adjusted for optimum bandpass response at the transmit output signal frequency. The output signal is routed through a diode switch which permits switchover to the hot standby transmitter in the event of a detected failure of the in-service transmitter.

The waveguide diode switch is controlled by a switchover control unit which monitors vital transmitter parameters. A simplified block diagram showing the hot standby transmitter switchover configuration is shown in Figure A5-2. The switchover control unit monitors the transmit output frequency accuracy via the AFC unit for both the in-service and hot standby transmitters. Upon detection of an out-of-tolerance condition in the in-service transmitter, the switchover control unit activates the waveguide diode switch to bring the hot standby transmitter on-line. In the event both transmitters report a fault, no switchover occurs, and the in-service transmitter remains on-line. Activation of the switchover control unit may also be accomplished manually or via remote control.

A5-1.2 Receiver Description

The following discussion refers to one of the receivers. The operation of the other receiver is identical. Figure A5-3 is a simplified block diagram of the radio receiver. The input signal frequency range is from 7125 MHz to 8400 MHz. The input signal passes through a manually operated waveguide shutter which is used to block the received signal or simulate a signal fade during receiver maintenance checks. The preselector filter is a 7-cell cavity filter with optimum passband response at the operating signal frequency. The input signal is coupled from the preselector filter to the mixer/preamplifier module through a 40 db load isolator. The load isolator isolates the preselector filter from impedance variations in the mixer. The mixer/preamplifier module uses a balanced rat race mixer to mix the input signal with a local oscillator signal at a frequency which is 70 MHz below that of the input signal. The local oscillator signal is phase locked to a high stability crystal reference which insures frequency accuracy and stability. The difference frequency after mixing is the 70 MHz IF signal which is amplified in the preamplifier and coupled through an equalizer module to the IF amplifier. The equalizer module uses two equalizer circuits that serve to compensate for phase distortion in the radio set, waveguide, and antenna.

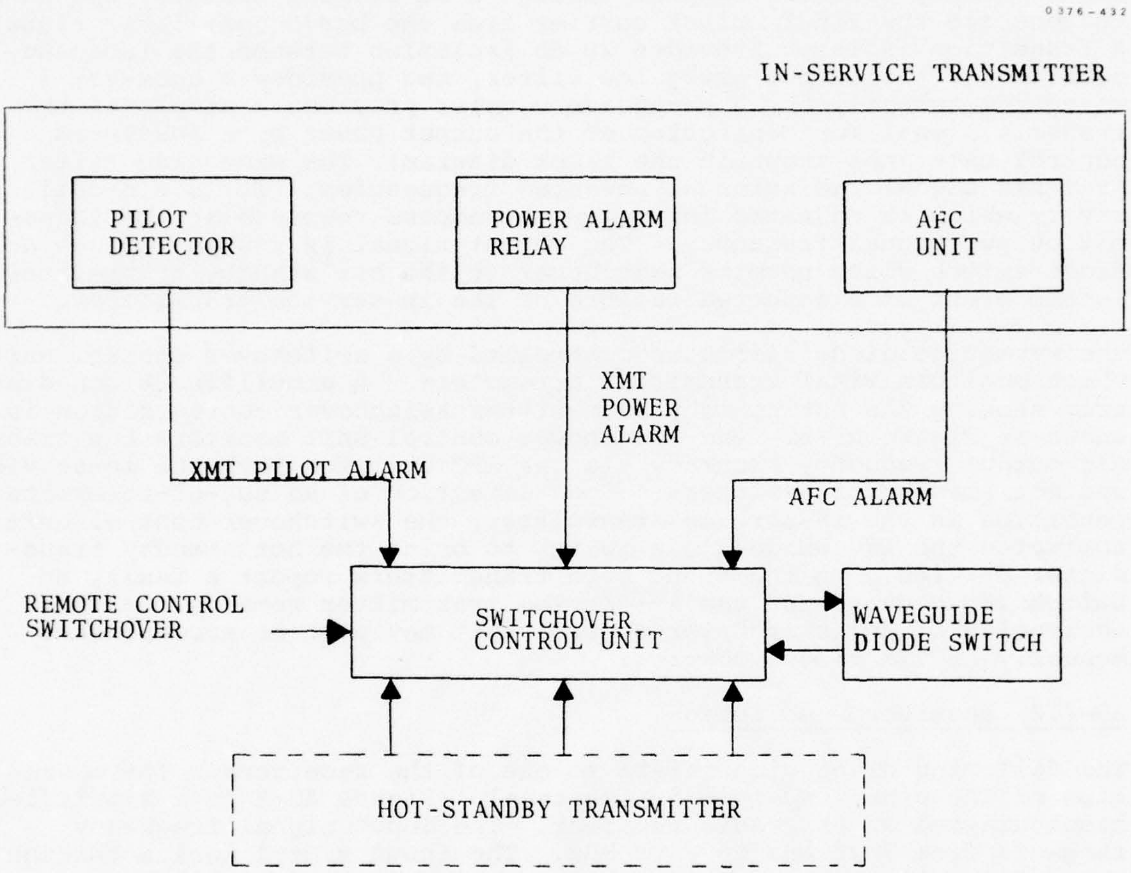


FIGURE A5-2. HOT-STANDBY TRANSMITTER SWITCHOVER

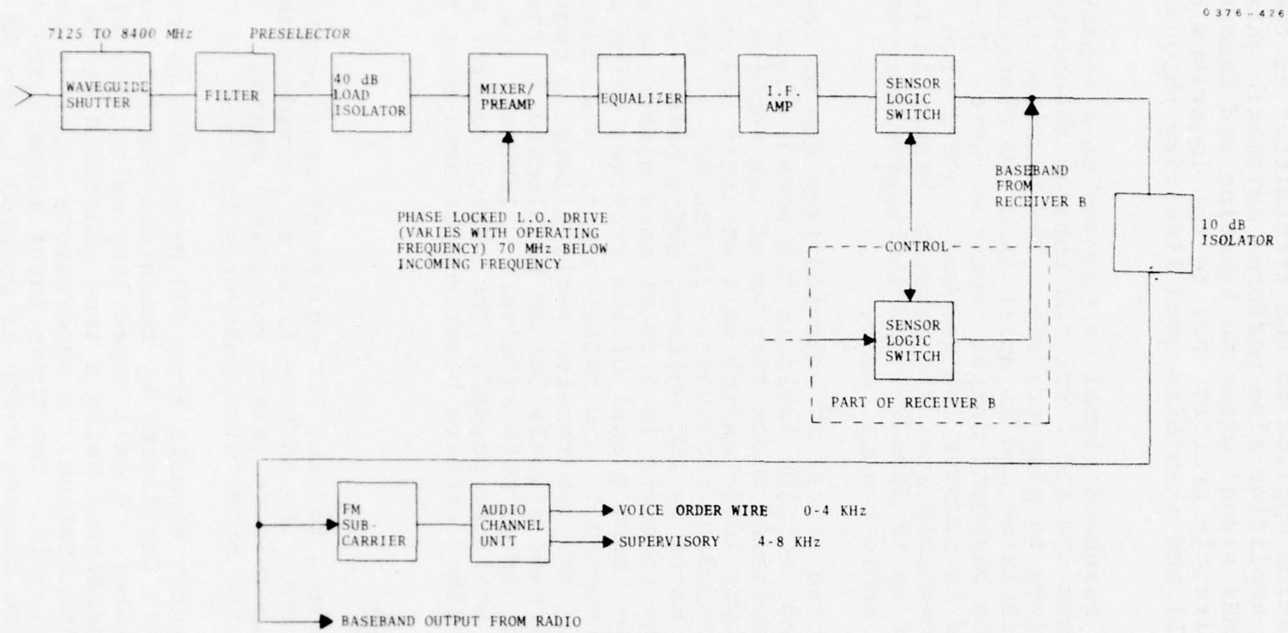


FIGURE A5-3. RADIO RECEIVER BLOCK DIAGRAM

The IF amplifier amplifies, limits and demodulates the 70 MHz IF signal. The demodulated signal is a composite baseband which contains all information applied to the transmitter at the distant station. The IF amplifier also performs automatic gain control (AGC) on the 70 MHz signal prior to limiting and demodulation. The AGC voltage is directly proportional to the logarithm of received signal level (RSL) and maintains good linearity throughout its operating range.

Each demodulated baseband signal is coupled to a sensor logic switch unit which monitors the AGC level and through associated logic control selects the receiver to pass traffic. The baseband signal passes through a 10 db isolator and is split into two channels. One channel is provided as the baseband output from the radio. The other channel is FM demodulated to recover the service channel from a 8.1 MHz subcarrier. After demodulation, the service channel is further split into the VOW (300 Hz to 3000 Hz) and the supervisory order wire (4 kHz to 8 kHz) in the audio channel unit.

The receive baseband signal is selected from one of the two receivers by the control and decision logic in the sensor logic switch. Figure A5-4 is a simplified block diagram of the receive baseband switch control. The sensor logic switch unit monitors and compares the AGC level from the redundant receivers. If the RSL in the operating receiver, as indicated by AGC voltage, drops below -66 dbm, and the RSL in the standby receiver is 5 db or more higher, a switchover occurs, and the baseband signal of the receiver which was initially in standby is connected to the radio output. A similar process occurs when one of the two receive radio pilots is degraded or lost. However, both baseband signals cannot be blocked in the event of the loss of pilot signals in both receivers. Instead, the better baseband signal will still be passed. The switch control unit can be manually set to either receive baseband for equipment testing or maintenance.

A5-1.3 Order Wire

The order wire system for the FKV equipment configuration uses the capability built into the AN/FRC-162(V) to provide both a voice order wire (VOW) and supervisory (alarm reporting) channel. A simplified block diagram of the order wire subsystem is shown in Figure A5-5.

The VOW accepts input signals from 300 Hz to 3000 Hz for voice communications between facilities by technical control operating and maintenance personnel. A call capability exists for alerting distant station personnel using a tone generated at 3821 Hz which signals the distant station. A supervisory input is provided and accepts 4-8 kHz signals. The three input signals are combined into a composite service channel which is coupled to the FM modulator module. The service channel modulates a 8.1 MHz subcarrier in the FM modulator module. The modulator subcarrier is combined with the input baseband and coupled to the modulation amplifier.

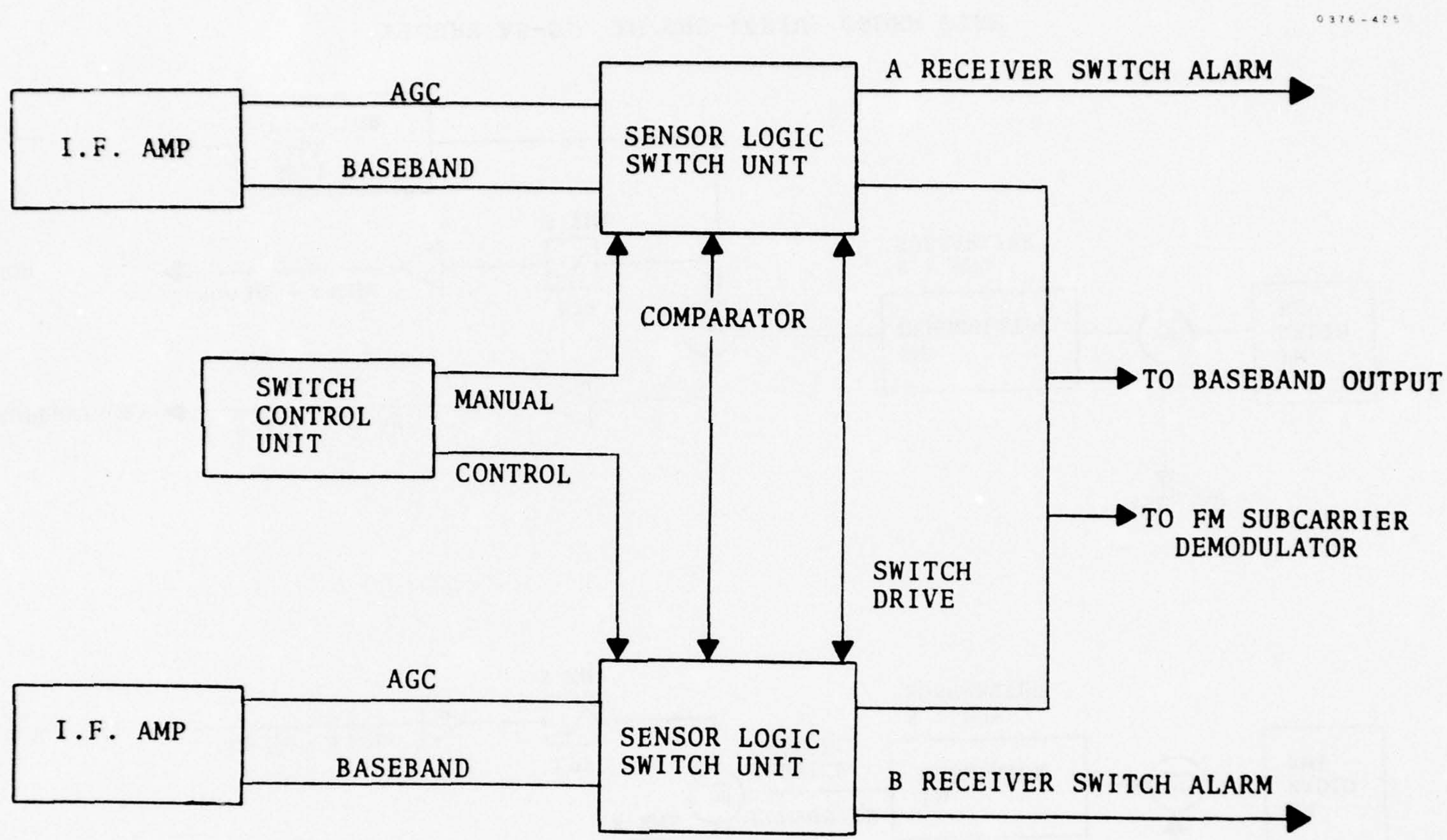


FIGURE A5-4. RECEIVE BASEBAND SWITCH CONTROL

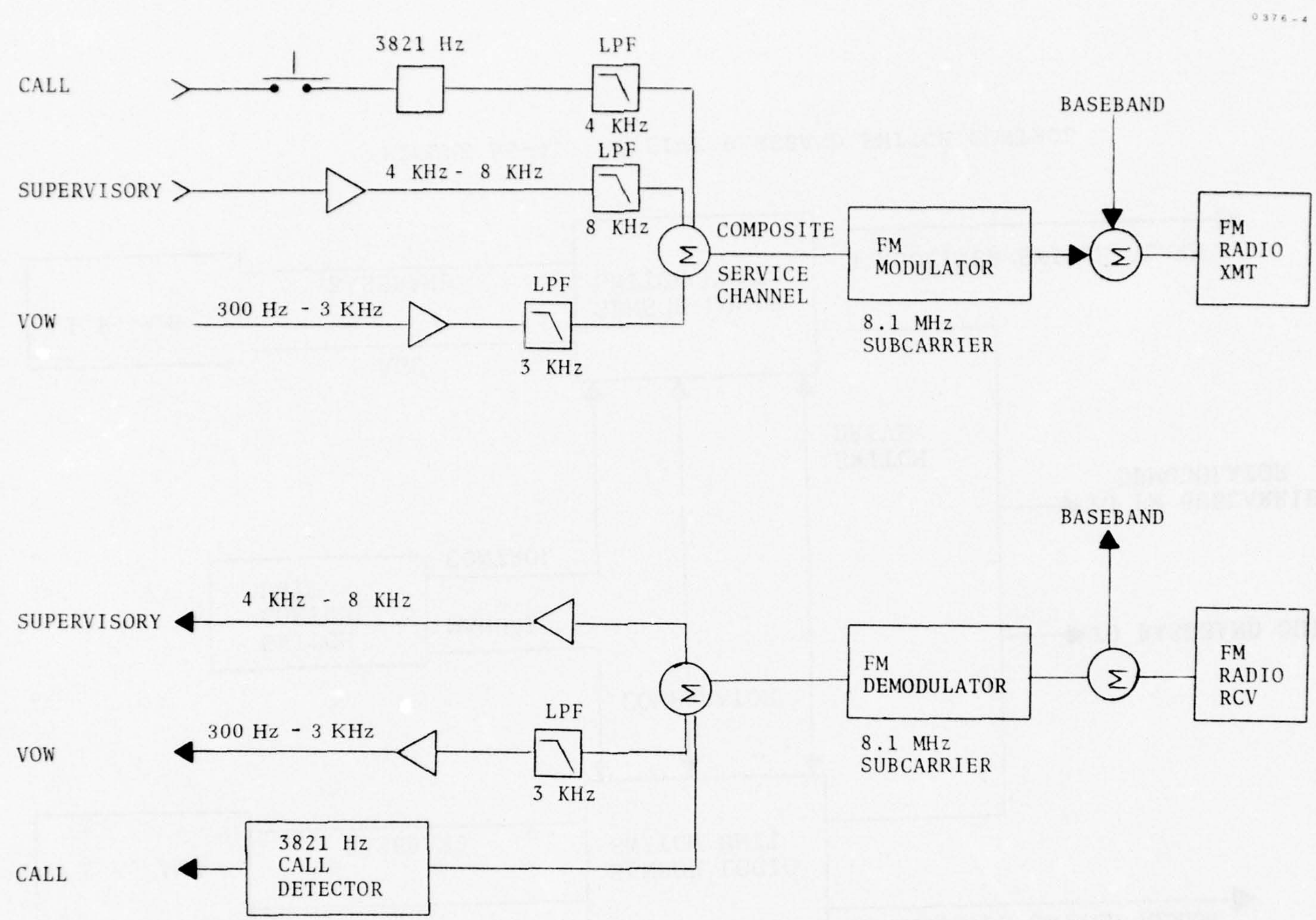


FIGURE A5-5. AN/FRC-162(V) ORDER WIRE

The remainder of the transmitter operation is described in the transmitter section.

The performance characteristics for the AN/FRC-162(V) radio set are listed in Table A5-1.

TABLE A5-1. AN/FRC-162(V) PERFORMANCE CHARACTERISTICS

Frequency Stability	0.0005 percent
Deviation	
Pilot	140 kHz rms
Supervisory	700 kHz peak
Data	3.14 MHz
Transmit Output Power	1 Watt (nominal) 0.5 Watt (minimum)
Return Loss Circulator Out	32 db
Receive Noise Figure	10 db nominal, 12 db maximum
30 db S/N (52 dba0) point	-77.5 dbm
Image Rejection	130 db minimum
IF Frequency	70 MHz
IF Bandwidth	

Bandwidth	Loading	Bit Error Rate at -71 dbm RSL
25 MHz	12.6 megabits/ second	1 in 10^7

Baseband Levels	
Input	
TDM	+2.5 ±0.5 dbm
Supervisory	-35 to -10 dbm
Output	
TDM	+2.5 ±0.5 dbm
Supervisory	-15 ±0.5 dbm
Pilot (Tx In)	-24 dbm0

TABLE A5-1. AN/FRC-162(V) PERFORMANCE CHARACTERISTICS (CONTINUED)

Service Channel	
Input	-15 to 0 dbm
Output	-15 to 0 dbm
Impedance	
TDM	75 ohms, unbalanced
Supervisory	75 ohms, unbalanced
Service Channel	600 ohms, balanced
Return Loss	
Supervisory and TDM Baseband	26 db
Service Channel	20 db
Frequency REsponse	
300 to 3000 Hz (service channel)	3 db
300 Hz to 8 kHz (supervisory)	3 db
300 Hz to 6.4 MHz	±1.5 db
Pilot	8.5 MHz
Input Power	
DC	44 to 56 volts

A5-2 EXPECTED FKV RADIO LINK CHARACTERISTICS

A5-2.1 Purpose

The design of a system for performance monitoring and trend analysis of the radio links comprising the system must be predicated on a conceptual model of how the system behaves. The purpose of this analysis is to provide this model in semiquantative terms.

Some of the results stated herein may appear to contradict the analysis done by Raytheon in Reference 9. The apparent conflict is due to the different objectives of the work. Long term performance averages are the criteria used for communications systems design, and are utilized in Reference 9. However, to design a near-real time monitoring system, the temporal behavior of the system must be expressed in a way which includes near worst case conditions.

A5-2.2 Description of Analog Systems

The analog portion of the FKV system consists of those elements shown in Figure A5-6. The signal is converted to digital form, remultiplexed and retimed at all sites except Schwetzingen. Consequently, for analog monitoring purposes all links may be considered independent (considering the Heidelburg-Koenigstuhl portion as one link), from an analog point of view.

Redundancy Features

The system is completely redundant at all levels with the exception of the transmitting antenna system and common baseband equipment. Switching is provided at the transmit multiplex output, the radio transmitter output to its antenna; the radio receiver-baseband output to the demultiplexer, and at the demultiplexer input.

Switching of the multiplexers is a relatively slow and cumbersome process, and is independent of the radio switching. Shifts to standby receive equipment are made when the primary equipment cannot reframe. Transmit equipment is switched upon generation of its own internal alarm, or upon receipt of an indication (Remote Alarm) from the far end that it cannot reframe with either primary or standby receive equipment.

The radio sets, in normal operation, are operating upon traffic over both parallel paths, even though only one is in use. Automatic switching of the transmitters is performed upon detection of loss of pilot, AFC, or RF power. Receiver switching is performed upon loss of pilot, or reduction of Received Signal Level (derived from AGC) below about -66 dbm, if the standby receiver has 5 db better received signal level (RSL).

Table A5-2 lists the conditions for switchover. Each condition except switching due to low RSL initiates an alarm.

It is expected that receive baseband switching due to low RSL will occur with errors of zero to a few bits (information received from Fort Huachuca indicates that, with proper phasing and adjustments, errorless switching is possible). Thus a coincidence of errors and baseband switchover is an indication of malfunction.

Other switching speeds are not known; however consideration of the circuitry involved and expected sensing times leads to the inference that an order of magnitude of hundreds of microseconds to tens of milliseconds is involved.

A5-2.3 Behavior of the Space Diversity System

A5-2.3.1 Propagation

In normal operation both radio receivers receive signals from one transmitter through separate antennas which are physically about 25 feet apart.

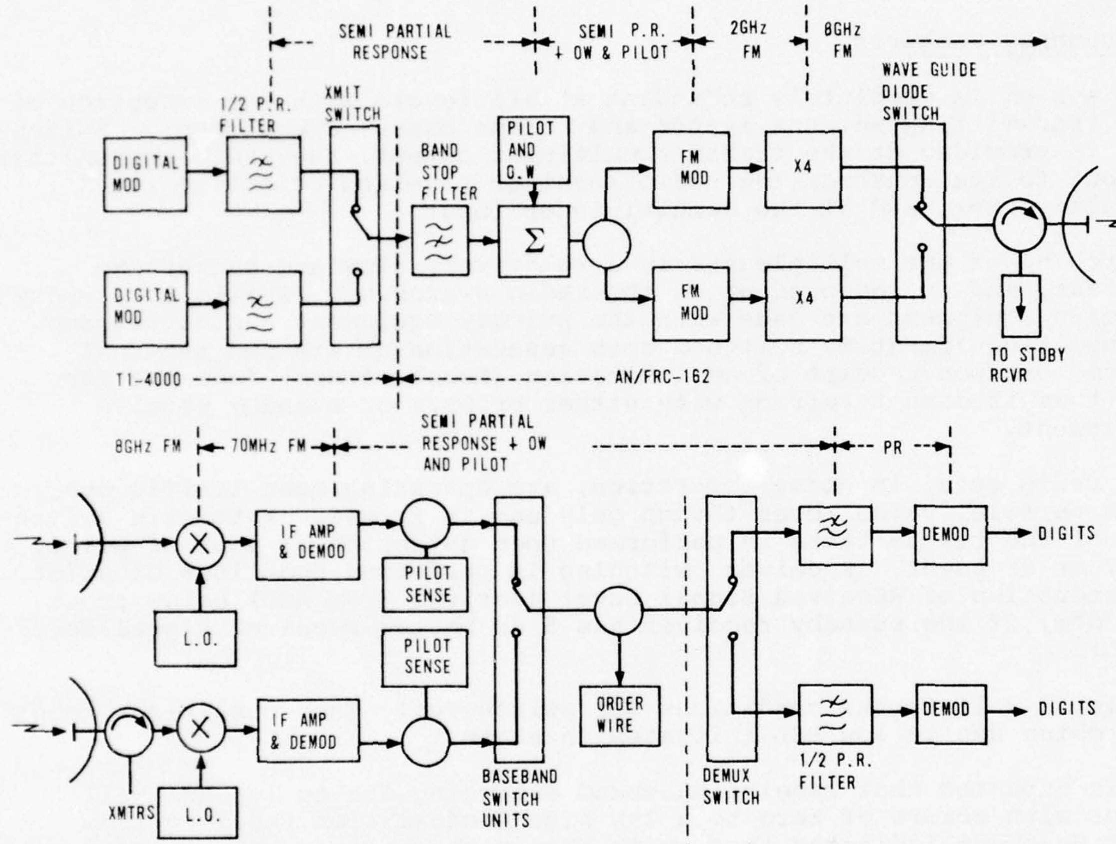


FIGURE A5-6. FINAL ANALOG SYSTEM, SHOWING
SIGNAL FLOW AND REDUNDANCY

TABLE A5-2. AN/FRC-162 SWITCHING CONDITIONS

Receiver Function	Conditions upon which switching occurs.
Loss of Pilot	If receive pilot drops below threshold and alternate channel pilot is above threshold (threshold field settable) (RELAY)
RSL Difference	If RSL (derived from AGC) is less than -66 dbm and alternate receiver AGC is X db higher (X is nominally 5, but is field settable. The -66 dbm may be altered by changing zener diode CR312).
Squelch	Circuitry exists in each individual receiver to switch relay contacts if RSL drops below Y dbm. In this equipment the function is used only to activate an alarm. (Y is field settable.)

NOTE: Two sets of spare logic inputs exist in each switching unit which may be used to base switching on other parameters.

Transmitter Function	
AFC	If AFC control voltage to FM modulator goes outside design range. Or AFC Control Phase Lock is lost (RELAY), and no fault is indicated on alternate transmitter.
Pilot	If baseband pilot level, as sensed at the output of the 2 gHz amplifier drops below preset level (threshold field settable) (RELAY) and no fault is indicated on alternate transmitter.
Power	If transmitted power, as sensed at wave guide falls below preset threshold (threshold field settable) (RELAY), and no fault is indicated on alternate transmitter.

Reference propagation conditions are usually considered to be those established in early afternoon, on a clear day, when the atmosphere is well mixed. Under these conditions, the received signal level is high, relatively stable, and has good coherence across the RF bandwidth. Small fluctuations, on the order of a decibel or less, with periods on the order of seconds, will normally exist due to atmospheric turbulence.

Fading conditions have been analyzed empirically, and the results reported in a series of articles in the Bell System Technical Journal (References 1-6). These results will be used in analyzing the behavior of the FKV links, with the realization that while they describe statistical generalizations from a limited data base, they also provide a much better insight into fade behavior than was previously available. Fading conditions analyzed include:

1. Shallow Fading Occurrence

   Most of the time the radio links will be in a slightly faded condition, with the received signal level (RSL) below the reference level. One of the Bell Laboratories experiments (Reference 3) found, on a 27 mile 6 gHz link, that the received signal level (RSL) could be described, within limits by a lognormal probability distribution (lognormal in level implies normal in db) with a mean of -6.0 db and a standard deviation (σ) of 5.2 db. The limits of validity of this expression are about $\pm 1\sigma$.

   The system is designed to be unaffected by shallow fading of this magnitude. However, it is a background process which must be recognized in the extraction of trending and performance assessment parameters.

2. Fading due to Rainfall and Fog

   Rainfall along the propagation path will cause flat, simultaneous fades in the RSL of the two diversity channels.

   Attenuation due to rain at 8 gHz may be roughly stated as follows (Reference 7).

   $$\alpha \approx 0.03 \text{ R}$$

   where α is attenuation in db per kilometer of path

   R is rainfall rate in millimeters per hour.

   Attenuation for the total path becomes the integral along the path

   $$A(db) = \int \alpha (l)\, dl \approx \int 0.03R\, (l)\, dl$$

   where A is the total attenuation along the path.

A qualitative feeling for rainfall effects is obtained by computing attenuation for the longest FKV paths. Assuming various average rainfall rates ($\bar{R}$) along the path:

Path	Length (km)	A Light Rain ($\bar{R}$=1 mm/hr)	A Moderate Rain ($\bar{R}$=4 mm/hr)	A Heavy Rain ($\bar{R}$=15 mm/hr)
SGT-STB	31.5	0.95 db	3.8 db	14.3 db
STB-KSL	61.7	1.5 db	6.0 db	22.5 db

Fog and water vapor along the path also introduce attenuation. Its magnitude is less than that for rainfall. Fog often exists in the conditions which are favorable for abnormal refraction, including multipath propagation.

3. "Earth Bulge" Fading

Atmospheric conditions can exist in which the direct ray path between transmitter and receiver is bent downward and contacts the Earth. The usual result of this condition is substantially increased attenuation which manifests itself first and most severely on the bottom antenna of a pair.

If the terrain along the path is reflective, such as a body of water, attenuation may not exist. This condition is, however, conducive to multipath propagation.

The path engineering of the FKV appears to be conservative in this respect. Earth bulge fading is not expected to be a practical problem.

4. Multipath Fading

The most severe fades occur during periods of multipath propagation, when energy can reach the receiving antenna by two or more paths. When this occurs, the phase and amplitude of the RF waves received over the different paths will vary. Occasionally the relationship between signals will be such that their vector sum is near zero. This is a deeply faded condition.

During normal, single path propagation conditions, variations of the amplitude and phase transfer characteristics across the signal bandwidth is negligible. However, in a deep multipath fade, the net received signal is nearly the difference of two normal signals. When this occurs, the variations, which are negligible on a single path assume potential significance.

The occurrence of multipath propagation is closely related to climate, season, weather, and time of day. Statistically speaking in temperate climates, multipath is most likely to occur in late summer and early fall, in calm weather, in the late night and early morning hours.

Space diversity provides considerable reduction in the effects of multipath fading because simultaneous fading rarely occurs at both receiving antennas.

a. Characteristics of Single Channel Fades (i.e., Non Diversity)

One way of expressing, and to some degree extrapolating the Bell Studies results (References 2, 3, 5) for a single path in the worst fading month is as follows:

Probability that signal amplitude V(t) will fade below a particular threshold level L (voltage) is:

$$P(V < L) = rL^2 \qquad \text{(Eq. 1)}$$

$$\bar{t} = 410L$$

$$\bar{N} = \frac{r}{410}L$$

where: $L \leq 0.1$ (-20dB)

and: V, L are the ratios of envelope voltages to reference envelope voltage

$\bar{t}$ is the average duration of a fade below L

$\bar{N}$ is the average number of fades per second (below L)

r is the multipath occurrence factor (which will be discussed later)

A "best fit" to the distribution of fade durations is given by:

$$P\left(\frac{t}{\bar{t}} > U\right) = 1/2 \text{ erfc } (0.555 \ln (U + 0.673))$$
(Reference 2)

where U is the ratio of fade duration at or below L to the average fade duration at or below L($\bar{t}$).

This expression is plotted in Figure A5-7.

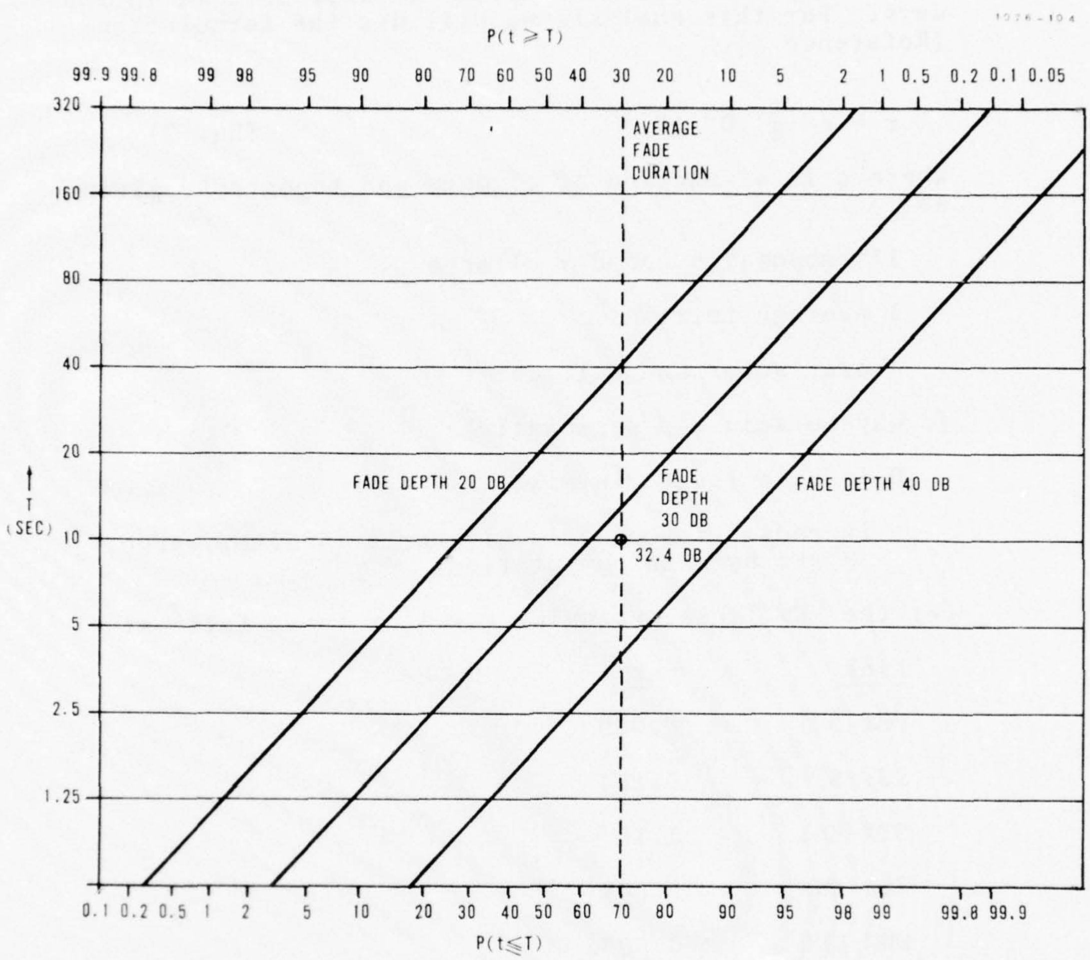


FIGURE A5-7. SINGLE PATH FADE DURATION DISTRIBUTION

The multipath occurrence factor is expressed in various ways. For this analysis we will use the formulation: (Reference 2).

$$r = c\ (\frac{f}{4})\ D^3\ 10^{-5} \qquad \text{(Eq. 2)}$$

where c is a function of climate and topography given as:

1/4 mountains and dry climate

1 average terrain

4 over water and Gulf coast

(c may be adjusted seasonally)

D is path length in miles

f is radio frequency in gigahertz (4-11gHz range, 8 gHz used in computation)

For the FKV links, assuming c = 1, r is as follows:

Link	r
VHN-SGT	0.009
SGT-STB	0.154
STB-KSL	1.16
KSL-SWN	0.008
SWN-HDG	0.0036

$\overline{N}$ can be expressed in fades per day or per month:

$\overline{N}_D$ = 211 rL, where $\overline{N}_D$ is the number of fades per day.

$\overline{N}_n$ = 6300 rL, where $\overline{N}_n$ is the number of fades per month.

A typical calculation using the VHN-SGT link would be

$$V = c\left(\frac{f}{4}\right) D^3\ 10^{-5}$$

$$V = 1\left(\frac{8}{4}\right)(7.7675)^3\ 10^{-5}$$ (NOTE: D = 12.5 km converted to miles)

$$= 2 \times 468.64477 \times 10^{-5}$$

$$= 937.28954 \times 10^{-5}$$

$= .009$ (to 3 significant places)

For the individual links of the FKV, for each diversity channel the expected number of fades per month in fading season, to or below stated level, is:

	20 db	30 db	40 db
VHN-SGT	6	2	<1
SGT-STB	97	30	10
STB-KSL	730	230	73
KSL-SWN	5	2	<1
SWN-HDG	1	-	-

b. In-Band Dispersion During a Fade

Dispersion created by nonlinear phase versus frequency characteristics of the RF path is a potential source of errors due to distortion of the baseband waveform. It is desirable to glean an approximate idea of the severity of this problem to estimate whether low signal to noise ratio or dispersion is likely to be the major contributor to errors. The analysis uses several approximations, and is intended as only a rough estimate of distortion.

Reference 5 describes the results of experimental measurements on a 6 gHz LOS link. Briefly, dispersion was found to be correlated with deep fading, often superimposed upon shallow, nondispersive fading. From the experimental data in the reference, the coefficients of the second degree approximation to the phase equation were calculated as:

$$\phi(f) = a + b_f + c_f^{\,2} \qquad \text{(Eq. 3)}$$

where:

$\phi(f)$ is phase shift across the RF signal bandwidth, as a function of frequency difference from the carrier

a is reference phase

b is linear shift (which does not create distortion)

c is parabolic phase shift

f is frequency in MHz

In only one fade of less than 40 db depth was c found to be more than 0.2 degree/(MHz)^2. This value will be used in our calculations in the FKV system; the digital waveform most likely to be affected is the repeating sequence 11001100----. This, after filtering, becomes a 3.15 MHz sine wave at baseband with a 3.15 MHz peak deviation.

The phase of the RF signal after traversing a system with parabolic delay distortion is given (Reference 7) by:

$$\phi out_{RF} = \cos\left\{\omega_c t + \phi(t) + b_2\left[\phi'(t)\right]^2 - \frac{b_2^2}{2}\phi''''(t)\right\} \quad \text{(Eq. 4)}$$

where ϕout_{RF} is the phase of the RF input to the demodulator

$\phi(t)$ is the intended phase shift of the baseband signal

ω_c is carrier angular frequency

b_2 is the parabolic phase coefficient expressed in suitable units.

primes denote derivatives with respect to time

The FM demodulation process produces an output voltage proportional to rate of change of phase with respect to the carrier:

$$Vout = \frac{1}{k}\, d/dt\left\{\phi(t) + b_2\left[\phi'(t)\right]^2 - \frac{b_2^2}{2}\phi''''(t)\right\} \quad \text{(Eq. 5)}$$

where k is the modulation sensitivity in radians/volt-second.

V_{out} is the demodulator output voltage

Performing the differentiation:

$$V_{out} = \frac{1}{k}\,\phi'(t) + 2b_2{}^2\,\phi'(t)\phi''(t) - \frac{b_2{}^2}{2}\,\phi''''(t) \quad \text{(Eq. 6)}$$

The FM-modulation equation is

$f = \phi'(t) = kV_{in}$, where V_{in} is the modulator input voltage

Substituting this in Equation 6;

$$V_{out} = V_{in} + 2kb_2V_{in}\,\frac{dV_{in}}{dt} - \frac{b_2{}^2}{2}\,\frac{d^4V_{in}}{dt^4} \qquad \text{(Eq. 7)}$$

The assumed waveform is $V_{in} = \cos\omega_m t$.

Substituting this in Equation 7; differentiating and simplifying:

$$V_{out} = \left(1 - \frac{b_2{}^2\omega_m{}^4}{2}\right)\cos\omega_m t - kb_2\omega_m \sin 2\omega_m t \quad \text{(Eq. 8)}$$

Substituting these values of the parameters

$k = 3.15 \times 2\pi \times 10^6$ radians/volt-sec

$b_2 = 8.8 \times 10^{-17}\,sec^2/rad$ (equivalent to $0.2^{\circ}/MHz^2$)

$\omega_m = 3.15 \times 2\pi \times 10^6$ rad/sec

$$V_{out} = (1 - 1.5 \times 10^{-6})\cos\omega_m t - 3.44 \times 10^{-2}\cos 2\omega_m t \qquad \text{(Eq. 9)}$$

As a percentage of the desired signal, the distortion is 3.44%.

Since the dispersion assumed was near worst case, exceeding once in a fade of less than 40 db, which is deeper than the fade margin of the FKV links, it is probable that, as a general rule, the links will produce significant errors due to low signal to noise ratio at fade depths less than or equal to those causing problems due to dispersion.

c. Characterization of Simultaneous Fades with Dual Space Diversity (Figure A5-8).

As would be expected, the average duration of fading in two channels is half that of a single channel.

The distribution of fade durations is given by Vigants (Reference 2) is

$$P\left(\frac{t}{\bar{t}} > U\right) = 1/2 \operatorname{erfc}\left(\frac{\ln \frac{U}{2} - \mu}{2\sigma}\right)$$

$$- \frac{U}{4} \exp\left(-\mu + \frac{\sigma^2}{2}\right) \operatorname{erfc}\left(\frac{\ln \frac{U}{2} - \mu}{\sqrt{2\sigma}} + \frac{\sigma}{2}\right)$$

This expression is plotted, approximately, in Figure A5-8. (The approximation is due to the limitations of the tables used.)

The lessening of the number of fades with sapce diversity can be expressed (References 2,5) as,

$$N_D = \frac{2}{Io} N_1$$

where

$$Io \cong \frac{1}{2.75} \frac{s^2}{\lambda d} L^{-2}, \text{ valid for } Io > 5$$

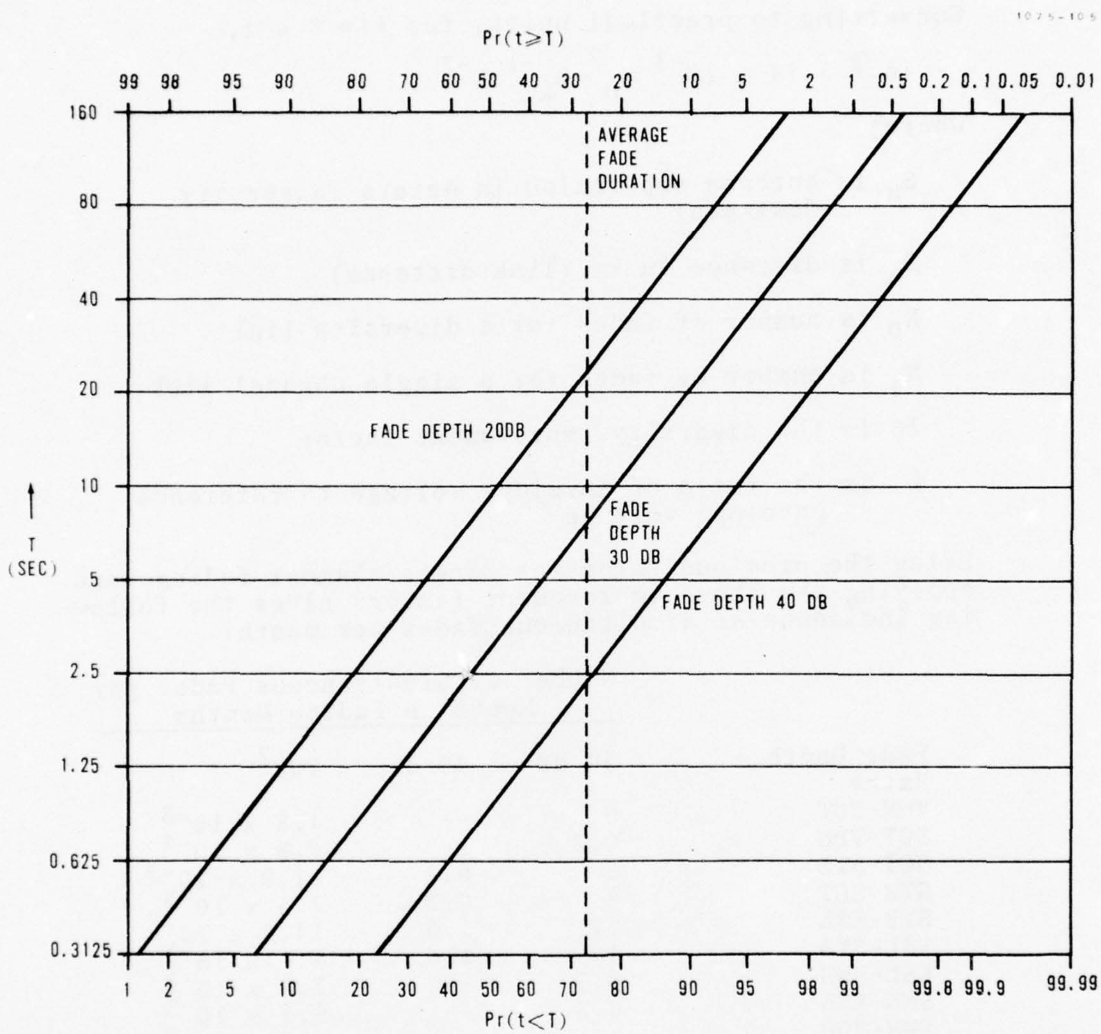


FIGURE A5-8. SPACE DIVERSITY FADING DURATION DISTRIBUTION OF SIMULTANEOUS FADES ON TWO CHANNELS

Converting to practical units, for f = 8 gHz,

$$Io \cong 3.74 \times 10^{-3} S_n^{\ 2} D_k^{\ -1} L^{-2}$$

where:

S_n is antenna separation in meters (diversity distance)

D_k is distance in km (link distance)

N_D is number of fades for a diversity link

N_1 is number of fades for a single channel link

Io is the diversity improvement factor

L is the ratio of envelope voltage to reference envelope voltage

Using the previous rates for single channel fading, and applying the above improvement factors gives the following incidence of simultaneous fades per month:

	Number of Simultaneous Fades per Month in Fading Months		
Fade Depth → Path↓	30 dB	40 db	IoL^2
VHN-SGT	0.8	--	4.8×10^{-3}
SGT-VHN	0.8	--	4.8×10^{-3}
SGT-STB	5	0.2	11.9×10^{-3}
STB-SGT	8	0.3	7.6×10^{-3}
STB-KSL	31	1.0	14.8×10^{-3}
KSL-STB	49	1.6	8.7×10^{-3}
KSL-SWN	0.5	--	7.5×10^{-3}
SWN-KSL	0.5	--	8.1×10^{-3}
SWN-HDG	--	--	6.5×10^{-3}
HDG-SWN	--	--	6.5×10^{-3}

Note that these characteristics are not necessarily reciprocal; this is due to differing antenna separations.

If the specified level, L, represents a particular signal to noise characteristic of the receiving system, it can be termed a threshold. Two particular values of L which are used are the FM threshold and the PCM threshold. The FM threshold is the value of received signal level below which the receiver signal to noise output is no longer

proportional to carrier to noise input. The PCM threshold is the RSL corresponding to a specified bit error rate; below it errors rise drastically with decreased RSL.

The term, time below threshold, is an important criterion of link performance. Its expected value is the product of the expected number of fades times the average fade duration.

For a single link:

$$\left(\frac{T}{TO}\right)_1 = P\ (v<L) = rL^2, \qquad \text{(Eq. 1)}$$

For a diversity link:

$$\left(\frac{T}{TO}\right)_D = \frac{1}{Io}\left(\frac{T1}{TO}\right) = \frac{1}{Io}\ rL^2$$

For a given link, however, Io is a constant multiplied by L^{-2}; therefore the expression can be written:

$$\left(\frac{T}{TO}\right)_D = \text{a constant } XL^4$$

where:

$\left(\frac{T}{TO}\right)$ is the fractional time below threshold.

D is defined in Eq. 4 and L in Eq. 1.

In terms of received signal power at threshold, for a single link

$$\left(\frac{T}{TO}\right) = \text{a constant X} \left(\frac{P_T}{PO}\right)$$

And for diversity link,

$$\left(\frac{T}{TO}\right) = \text{another constant X} \left(\frac{P_T}{PO}\right)^2$$

where:

PT is carrier power at threshold.
PO is reference power.

The implications of these relationships for performance assessment of space diversity systems lie in the square law dependence of time below threshold upon the carrier power at threshold. An increase in threshold caused, for example, by interference, carries a more severe relative performance penalty than in a single link.

d. Receiver Switching Frequencies with Dual Space Diversity

The expression for the number of fades for a single channel of a diversity pair is given previously.

For two channels in diversity, an approximation to the switching action may be derived thus.

If the fade depth at which switching occurs is the same in both receivers, each receiver will be operating half of the time and in standby half of the time. Assume independence of each channel.

Neglecting the second order case when switching does not occur due to both channels being faded, one-half of the fades in each channel will occur when it is nonoperational. Hence, the expected number of switchovers is approximately equal to the number of single channel fades.

Another approach is that fades occur in pairs, with the probability equal that a fade will occur first on the operating antenna. (Note statistics are not independent in this case.) In this case, when the operating channel switches, the probability is 1/2 that the new channel will experience a fade, and cause switching back.

Under this assumption, number switchovers approximately 3/2 number of single channel fades.

A5-2.3.2 Effects of Radio Interference

Radio interference, arriving through the receiving antennas, is an obvious potential contributor to system degradation. Interference can be natural, such as radiation from lightning bursts; inadvertent, such as sideways scattering of co-channel energy in rainfall, or deliberate.

For purposes of this discussion, interference will be classified into categories of relatively steady state, and pulse type interference:

1. Steady State Interference

Reference 8 reports the results of experimental determination of the effects of interference on a system similar to the FKV. The interfering signals were a single frequency sine wave (CW) and another 3 level partial response-- frequency modulated signal of the same characteristics.

Figures A5-9, A5-10, and A5-11 show the effects of, respectively, CW and 3LPR-FM interference. The salient points to be observed from these graphs are:

a. A carrier to interference ratio (C/I) of -15 db is enough to cause the received signal level (RSL) required to achieve a specified bit error rate to rise significantly. This amount of interference corresponds to a power ratio of carrier plus interference to carrier [(C+I)/C] of only 0.15 db. With increasing signal power, at the same C/I ratio, performance improves, as would be expected from the FM capture effect. This threshold shift is probably the most deleterious effect of interference.

b. The effects of interference, even within the receiver passband, are strongly dependent upon the frequency difference of the interference from the signal center frequency. This strong dependence is consistent with the expected behavior of an unequalized FM system, as the FKV is.

c. Interference of some types will cause a strong increase in the apparent noise floor in the order wire channel.

2. Noise Pulses and Bursts

Noise pulses, as the term is used here, are individual packets of energy whose amplitude is noticeably above the noise floor of the FM receiver. Their duration may range from a fraction of a bit time to many milliseconds. A noise burst is a grouping of noise pulses, as occurs during a lightning stroke.

The most honest statement to be made is that at this time we don't know enough about the mechanisms and

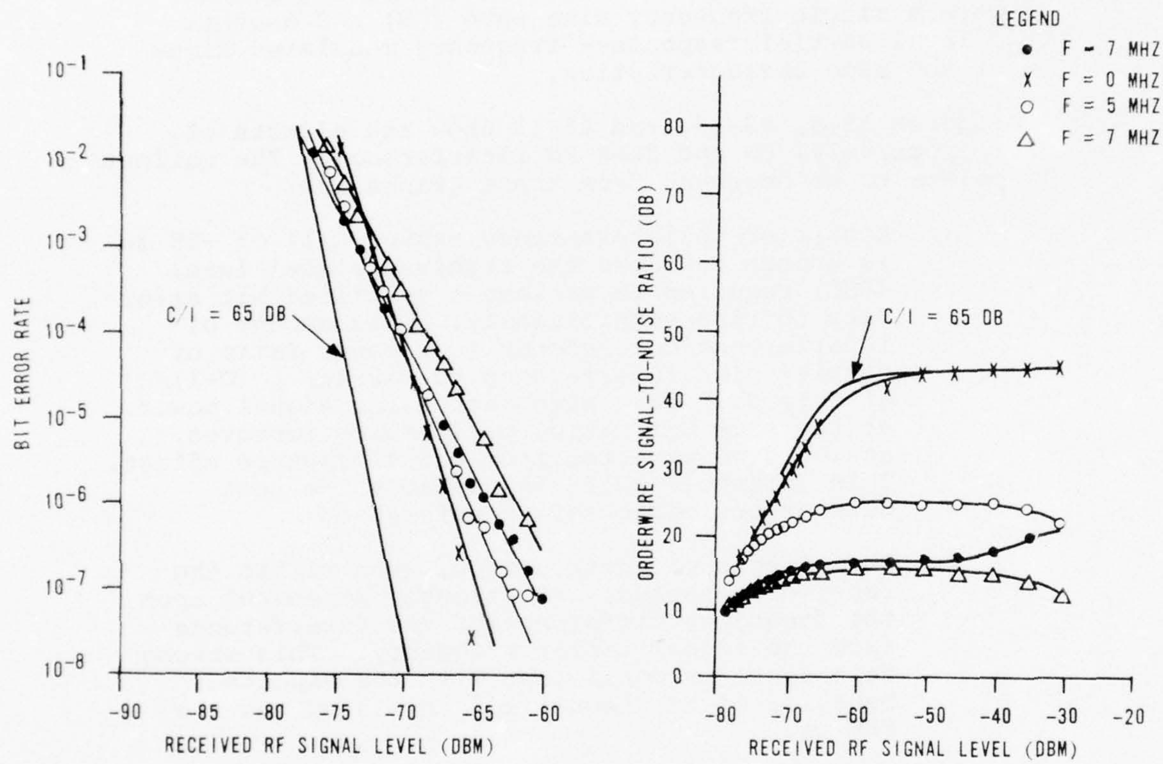


FIGURE A5-9. BER AND ORDER WIRE PERFORMANCE AS A FUNCTION OF RECEIVED SIGNAL LEVEL AND INTERFERING FREQUENCY DISPLACEMENT AT f_o, f_o - 7, f_o + 5, AND f_o + 7 MHz. TDM-PM WITH CW INTERFERENCE AT A C/I OF 15 DB

AD-A033 538 HONEYWELL INC ST PETERSBURG FLA AEROSPACE DIV F/G 17/2
ATEC DIGITAL ADAPTATION STUDY. VOLUME I. FKV REQUIREMENTS FOR P--ETC(U)
OCT 76 T R ARMSTRONG, A K BLOUGH F30602-75-C-0282
UNCLASSIFIED 476-13656-VOL-1 RADC-TR-76-302-VOL-1 NL

5 OF 5
ADA033538

END
DATE
FILMED
2 -77

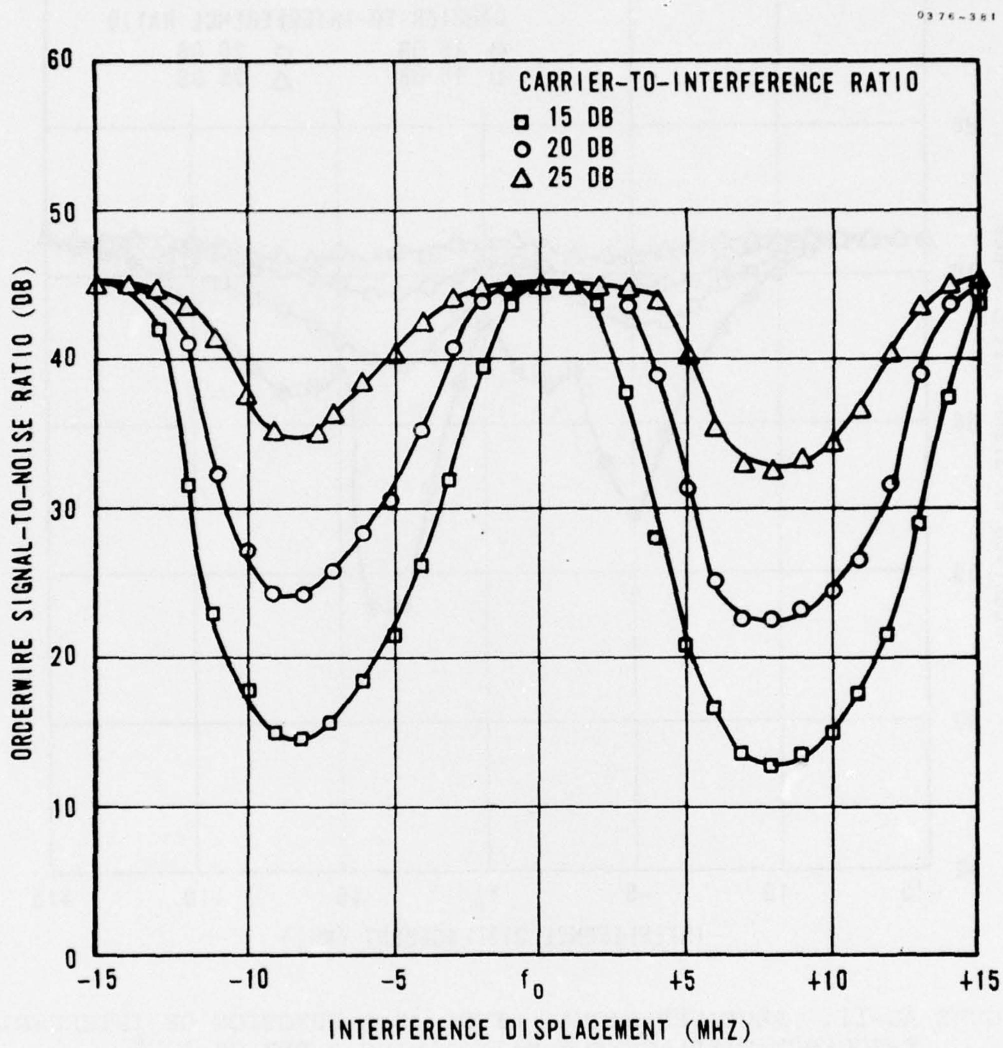


FIGURE A5-10. ORDER WIRE PERFORMANCE SIGNAL-TO-NOISE RATIO AS A FUNCTION OF INTERFERING FREQUENCY DISPLACEMENT MAINTAINING AN RSL OF -50 DBM

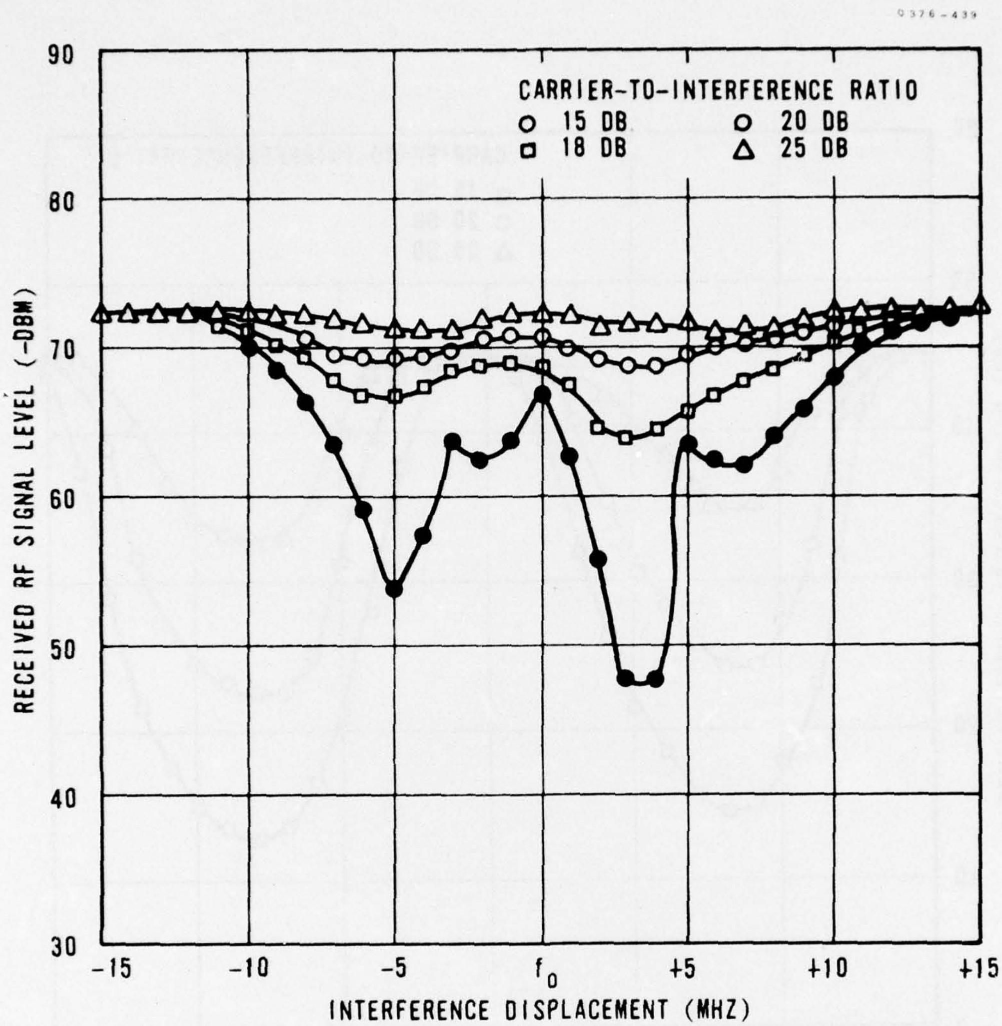


FIGURE A5-11. RECEIVED SIGNAL LEVEL AS A FUNCTION OF INTERFERING FREQUENCY DISPLACEMENT MAINTAINING A BER OF 10^{-6}

characteristics of natural sources of this type to quantify their effects. Consequently, this discussion will be qualitative in nature.

The effect of noise pulses at baseband is to suppress the signal waveform and superimpose upon it a noise-like signal for the duration of the pulse. If the pulse is strong, a short recovery time is involved in the AGC circuitry regaining its normal operating point; however, the baseband waveform should revert to near normal within a few bit times.

A thorough analysis of these effects as they relate to system operation would involve knowledge of the spectral, temporal, and spatial distribution of energy from lightning strokes; relating these to the receiving antenna characteristics, and hence through the receiver characteristics. A scarcity of information in many of these categories preclude analysis.

The most serious potential effects of this type of interference are not in the bit errors which would be introduced into the digital stream. Rather, they are (1) possible loss of main framing in the multiplexer, and (2) possible loss of bit integrity in the 1.544 mb subchannels caused by misinterpreted stuff control instructions.

A5-2.4 List of References

1. "The Number of Fades in Space Diversity Reception" by Arvids Vigants, BSTJ, Spetember 1970.
2. "Number and Duration of Fades at 6 and 4 gHz" by Arvids Vigants, BSTJ, March 1971.
3. "Multipath Propagation at 4, 6 and 11 gHz" by W. T. Barnett, BSTJ, February 1972.
4. "Selectively Faded Nondiversity and Space Diversity Narrowband Microwave Radio Channels" by G. M. Babler, BSTJ, February 1973.
5. "Phase Dispersion Characteristics During Fade in a Microwave Line of Sight Channel" by M. Subramanian, K. C. O'Brien, and P. J. Puglis, BSTJ, December 1973.

6. "Space-Diversity Engineering" by Arvids Vigants, BSTJ, January 1975.

7. "Transmission Systems for Communications", Bell Laboratories Staff, Fourth Edition, January 1970.

8. "Measurement of Interference Effects Between TDM-FM and FDM-TM Microwave Systems" by D. Smith and F. G. Kennett, Department of Commerce, Office of Telecommunications Technical Memorandum 75-194, March 1975.

9. "System Engineering Plan, Volume I, FKV Project", Raytheon - Europe Electronics Company, August 1974.

A5-3 CANDIDATE MONITOR POINTS FOR THE FKV RADIO

<u>AN/FRC-162 Switching Conditions</u>

RECEIVER

Function	Conditions upon which switching occurs.
Loss of Pilot	If receive pilot drops below threshold and alternate channel pilot is above threshold (threshold field settable) (RELAY)
RSL Difference	If RSL (derived from AGC) is less than -66 dbm and alternate receiver AGC is X db higher (X is nominally 5, but is field settable. The -66 dbm may be altered by changing zener diode CR 312).
Squelch	Circuitry exists in each individual receiver to switch relay contacts if RSL drops below Y dbm. In this equipment the function is used only to activate an alarm. (Y is field settable)

NOTE: Two sets of spare logic inputs exist in each switching unit which may be used to base switching on other parameters.

TRANSMITTER

Function AFC	If AFC control voltage to FM modulator goes outside design range. Or AFC control phase lock is lost (RELAY), and no fault is indicated on alternate transmitter.
Pilot	If baseband pilot level, as sensed at the output of the 2 GHz amplifier drops below preset level (threshold field settable) (RELAY) and no fault is indicated on alternate transmitter.

AN/FRC-162 Alarms

Unless noted, these alarms are available as a contact closure or opening, selectable at J103 and J104 in the A and B equipments, respectively.

1. Transmit Power (each transmitter): Alarms when transmitter output power, sensed at an 8 GHz directional coupler at the transmitter output, decreases below a preset threshold. Alarm threshold is field adjustable.

2. Transmit AFC (each transmitter): Indicates that transmit AFC voltage falls outside normal range of +5 to +15 volts, and/or that the phase lock loop in the AFC reference unit lost lock. Disabled when AFC is manually switched OFF. Threshold not adjustable.

3. Transmit Pilot (each transmitter): Indicates that pilot level, as sensed at 2 GHz coupler and demodulated, has dropped below threshold. Alarm threshold is field adjustable. 70 MHz switch on subsystem control unit must be on XMT.

4. Pilot Oscillator (Common Transmit Baseband Equipment): Indicates that pilot oscillator level has dropped below preset threshold, which is field settable. Available at P2 on oscillator as a DC voltage.

5. FM Subcarrier (Common Transmit Baseband Equipment): Indicates that service channel subcarrier level is below threshold. Threshold adjustable. Available at P1 on modulator as a contact opening or closure.

6. Receive Switch (each receiver): The conditions for switching to the alternate receiver other than low RSL have been met. In this radio set only low received pilot level will actuate this alarm. Alarm threshold is field settable.

7. Receive Squelch (each receiver): The squelch circuitry can be used, in some configurations, to inhibit receiver baseband output when received signal level is below a field set threshold. The output inhibiting functions are not used in this (AN/FRC-162) radio. However, the alarm functions are available. (NOTE: This circuitry is a candidate for inhibiting receive multiplexer switch-over when both radio set outputs are unusable due to low RSL.)

8. Receiver Phase Lock (each receiver): The receiver local oscillator has lost phase lock with the reference oscillator. Not field settable.

9. Receive Switch Control Unit (Common Receive Baseband Equipment): Alarms upon detecting abnormality in switching. Available at connector P101 of the switch control unit, as a contact opening/closure.

10. Receive Subcarrier Demodulator (Common Receive Baseband Equipment): Activates upon the received subcarrier level of service channel dropping below threshold. Threshold activated. Available at connector P1 as a contact closure or opening.

<u>Power Supply Alarms</u>

All power supply alarms indicate that the monitored voltage has dropped below the threshold at which an electromechanical relay opens. The alarms are:

11. Tx/Rx Power Supply (A&B): This monitors the +24 and -20V. DC used to operate each transceiver. The relays are wired at an "OR" gate; failure of either supply actuates the alarm.

12. Ancillary Power Supply (A&B): This monitors the -20V DC supplies used in the supervisory units, pilot oscillator, and S/L/S unit.

13. Primary Power (A&B): This monitors the 48V DC which is primary power to the entire unit.

14. Fuse Alarm: This alarms when one or more of the power supply fuses blows (and power is still available to actuate the alarm circuitry). Available at TB-4 and J4 as a DC voltage.

AN/FRC-162 Status Indicators

These are states of the equipment, not in themselves performance or fault indicators:

Switchover Control Unit (Transmitter)

15. Off Normal - Available internally to unit. Indicates normal transmit switching is inhibited by selection, manually, of one transmitter.

16. In Service (A&B) - Available as contact closures on K2 & K3 in unit; also as a voltage at plug. Indicates that transmitter is the operational unit carrying traffic.

17. Tx Transmitter Fault - Available as an OR'd function of Items 1, 2, 3.

Switch Control Unit (Receiver)

18. Off Normal - Available at terminals 9 & 11 of P101 as one of two voltages to ground (-20V). These indicate which receiver has been manually locked out, or at pin 55 as a relay ground indicating that either one has been manually selected.

19. In Service (A&B) - Available as contact opening/closure, pins 3 & 4 of each S/L/S connector. Indicates that the receiver is the operational unit carrying traffic.

20/ RCVR Available: J2, pin 42 (meter & control); J101,
21. AGC pin 22, 29

Electrical Nature: 2 to 8 Volts. Logarithmic 10 db per volt.

Indicative of: Total Signal & Interference Power Receive at Antenna.

Field Adjustable: Yes, in setting basic AGC loop gain.

22/ 23. RCVR FREQ

Available: J2, pin 24; J101, pin 23

Electrical Nature: DC Voltage, nominal OV

Indicative Of: Average frequency of received signal with respect to nominal.

Field Adjustable: No, except in discriminator alignment.

24/ 25. RCVR PILOT

Available: Each Receiver; SLS Unit, at J2 and pin pin 28 of connector board in S/L/S Unit.

Electrical Nature: D.C. Voltage, proportional to pilot amplitude. Nominally -2 volts.

Indicative Of: Gain adjustments in baseband circuitry (to point of sensing), and deviation adjustments in far end modulator and near end demodulator.

Field Adjustable: Yes. Gain of pilot sensing circuitry is field set.

26/ 27. RCVR SLOT NOISE

This candidate was rejected (refer to Paragraph 3.8.2).

28/ 29. RCV DEV TEST

Available: Internal to Subsystem Control Unit.

(This measurement analogous to XMT DEV TEST). ("70MHz" switch must be in "RCV").

30. RCVR BASE-BAND

Available: Several points. Low Level BB not used in set. Available as buffer amplifier.

Electrical Nature: Analog signal including traffic channel, FM subchannel & pilot.

Indicative Of: Signal can be analyzed in terms of traffic signal to noise; orderwire signal to noise; eye opening.

Field Adjustable: Yes.

AN/FRC-162 Analog Parameters

31/ 32. XMT PWR

Available: P108, pin 50 (raw); Internal to Subsystem Control Unit (filtered, buffered, and amplified).

Electrical Nature: Raw-rectified sample of 8 GHz output from waveguide coupler. If used in this form, would require buffering and isolation. Range not readily determinable; Linearity not readily determinable.

Indicative Of: Transmitter Output Power (RF).

Field Adjustable: Not in raw form.

33/ 34.	XMT FREQ	Available: P108 pins 44 & 46; P107 pins 6 & 8.
		Electrical Nature: D-C Voltage from discriminator in 70 MHz AFC Circuit.
35/ 36.	XMT DEV TEST	Available: Internal to Subsystem Control Unit.
		Electrical Nature: DC voltage. Normal level unknown. Derived from demodulated radio pilot as sensed at 2 gHz intermediate frequency of transmitter.
		Indicative Of: Change of transmitter deviation sensitivity.
		Field Adjustable: Yes. This measurement is dependent upon adjustment of transmit pilot oscillator; FM demodulator in the AFC unit, adjustment of the pilot detector, and adjustment of the metering circuit, as well as actual deviation. NOTE: 70 MHz switch must be in XMT position for this measurement.
37/ 38.	NOISE BURST	This candidate was rejected (refer to Paragraph 3.8.2).

A5-4 AN/FRC-162 PARAMETER AND ALARM ANALYSIS DATA

Alarms

1. Transmitter Power (A&B)

Usefulness

PA/TA-1
Not useful. Power transients very unlikely.

FI-4
Required for isolation of source of signal loss, and cause of switching.

Availability -4

External connectors at J103 and J104

Processing -4

None required.

2. Transmitter AFC (A&B)

Usefulness

PA/TA-1
Not useful. Transients are unlikely.

FI-4
Isolates the source of an off-frequency condition, in conjunction with receiver frequency.

Availability -4

External connectors at J103 and J104

Processing -4

None required.

3. Transmitter Pilot (A&B)

Usefulness

PA/TA-1
Not useful. Transients are unlikely.

FI-4
In conjunction with receiver switch, isolates source of pilot loss to transmitter.

Availability -4

External connections at J103 and J104

Processing -4

None required.

4. Transmitter Pilot Oscillator (A&B)

Usefulness

PA/TA-1
Monitors only the oscillator itself.

FI-2
Can determine that pilot associated faults are due to pilot oscillator failures. However, this can be inferred from loss of pilot indicated in both transmitters and both receivers.

Availability -3

Available at P2 on oscillator as a dc voltage.

Processing -4

None required.

5. FM Subcarrier Modulator (Common-Transmit)

Usefulness

PA/TA-4
If order wire subchannel is used for monitoring system telemetry, its loss indicates loss of monitoring capability.

FI-4
Same rationale as above.

Availability -3

Available at internal connector, P1 on subcarrier modulator.

Processing -4

None.

6. Receiver Switch (A&B)

Usefulness

PA-TA-1
In this set, this is essentially a threshold on receiver pilot level, not expected to vary transiently.

FI-4
In conjunction with transmitter pilot alarm, can be used to isolate source of apparent deviation loss.

Availability -4

Available at external connector at J103 and J104.

Processing -4

None.

7. Receiver Squelch (A&B)

Usefulness

PA/TA-4
Usable to trend "time below threshold" of the radio receiver.

FI-4
Can be used to establish low signal as a probable cause of transient degradation in other parts of the system.

Availability -4

External connections at J103 and J104.

Processing -2

Full utilization of this alarm requires timing and correlation with reframe indications, and between the two receiver alarms.

8. Receiver Phaselock (A&B)

Usefulness

PA-TA-1
This phenomenon unlikely to exhibit transient behavior.

FI-2
Useful for verification of the source of a receiver frequency drift.

Availability -4

External connector at J103 and J104

Processing -4

None required.

9. Receiver Switch Control (Common)

Usefulness

PA-TA-3
While not a performance indicator in itself, this alarm is useful to indicate that the receiver transfer circuits may not be functioning properly, and, therefore, information derived therefrom may be inconclusive or erroneous.

FI-3
This is a positive, but not all-inclusive indication that diversity protection has been lost.

Availability -3

At internal connector, P101 of subsystem control unit.

Processing -4

None required. If used to modify information derived from receiver switching, some software development is needed.

10. Receiver Subcarrier Demodulator (Common)

Usefulness

PA-TA-4
It ispresumed that the monitoring system uses the service channel for telemetry. If this is so, loss of the service channel causes loss of all monitoring capability.

FI-4
In addition to the above rationale, this alarm is useful in isolating the locus of a fault detected as loss of signal in the multiplex demodulator.

Availability -3

At internal connector, P101 on demodulator.

Processing -4

None required.

11. Transmitter and Receiver Power Supply (A&B)

Usefulness

PA/TA-1
This is a secondary parameter, unlikely to exhibit transients.

FI-2
Allows localization of the source of faults to the power supply module.

Availability -4

Intended for external connection at J103 and J104.

Processing -4

None required

12. Ancillary Power Supply (A&B)

Usefulness

PA/TA-1
This is a secondary parameter, unlikely to exhibit transients.

FI-2
Allows locatization of the source of faults within the equipment itself.

Availability -4

Intended for external connection at J103 and J104.

Processing -4

None required.

13. Primary Power (A&B)

Usefulness

PA/TA-1
The radio set is very uncritical of power supply voltage, and transients are unlikely.

FI-1 to 3, depending on telemetry used.
If telemetry is independent of radio and station power, the type of maintenance action required is determinable from this alarm. If telemetry is integral, it will be lost and no individual alarm information conveyed.

Availability -4

Available at external connectors J103 and J104.

Processing -4

None required.

14. Fuse Alarm

Usefulness

PA/TA-1
By its basic nature, this alarm does not exhibit transient behavior.

FI-2
Allows determination of the cause of an equipment failure.

Availability -3

Available at TB-4 and J4 as dc voltage.

Processing -4

None required.

AN/FRC-162 Radio, Status Indicators

15. Transmitter Off Normal

Usefulness

PA-TA-1
Indicates the position of a front panel switch which inhibits automatic switchover.

FI-3
Indicates that normal switchover of the transmitter has been inhibited. Transmitter redundancy has been lost.

Availability -1

Requires internal access to subsystem control unit indicated by position of switch S1.

Processing -4

None required.

16. Transmitter In-Service (A&B)

Usefulness

PA/TA-4
This information is required to determine what signal path is being tracked.

FI-3
This is necessary to determine which equipment is the potential source of observed far end degradation.

Availability -3

Available at connector board to switchover control unit.

Processing -4

Per se, no processing is required.

17. Tx Transmitter Fault

Usefulness

PA/TA-1
Transient behavior of this indicator is unlikely.

FI-1
This is an "OR" state of the three main transmitter alarms. It may be useful, as such, if telemetry capability is limited.

Availability -1

Requires internal access to subsystem control unit, across lamp DS-4.

Processing -4

None required.

18. Receiver Off Normal

Usefulness

PA/TA-1
This indicates the position of a front panel switch, which inhibits automatic switching.

FI-3
Indicates that normal diversity protection has been precluded.

Availability -3

Available at internal connector, P101 of switch control unit.

Processing -4

None required.

19. Receiver In-Service (A&B)

Usefulness

PA/TA-4
Indicates which system is responsible for effects observed at baseband.

FI-3
Necessary to determine which receiver is responsible for a fault observed in the demultiplex.

Availability -3

At internal connector, pins 3 and 4 of each S/L/S unit.

Processing -4

None required.

AN/FRC-162 Radio, Analog Monitor Points

20/21. Receiver AGC (A&B)

Usefulness

PA/TA-4
Presumptive indicator of received signal level. Long term statistics on the correlation with transmitter power, and between receivers, provide indication of deterioration in the signal path from transmitter to IF amplifier including waveguides, antennas, mixer and preamplifier. Correlation with eye pattern measurements can establish presumptive system waveform degradation and decrease of threshold.

FI-4
The alarms (squelch and switch), if properly set, provide capability to isolate a hard fault to the receiver. However, sources of degradation cannot be examined without correlation with RSL.

Availability -3

Internally at test point and J101 in IF amplifier module.

Processing -2

Hardware required to achieve RSL eye pattern coordinated measurements. ATEC software exists to trend AGC, but not for correlation with eye pattern results.

22/23. Receiver Frequency (A&B)

Usefulness

PA/TA-1
Frequency derived from discriminator average voltage, is an indicator of equipment frequency drift in both transmitter and receiver. Assuming signal quality is monitored at baseband, this becomes a secondary performance parameter.

FI-3
Useful for determining source of signal degradation observed at baseband. This provides different information from the receiver phaselock alarm.

Availability -3

At internal interconnections, J2 in metering unit; J101 in IF amplifier unit.

Processing -4

Can be processed by existing ATEC software.

24/ 25. Receiver Pilot (A&B)

Usefulness

PA/TA-1
Asecondary parameter, presumptively indicative at the net effects of changes in modulator and demodulator deviation sensitivity.

FI-3
Allows determination of improper deviation, and, interconnection with transmitter frequency, isolation to receiver or transmitter.

Availability -3

At internal connectors, J1 in S/L/S unit.

Processing -4

Can be processed by existing ATEC software.

26/ 27. Receiver Slot Noise (A&B)

Usefulness

PA/TA-2
In connection with AGC, with correlated interpretation, somewhat useful for detection of non-RSL related degradation at baseband repeater sites. Does not provide information as conclusive as provided by eye pattern monitoring.

FI-2
Usable for detection of intermodulation sources at baseband repeater sites.

Availability -4

Can be derived from any baseband output.

Processing -3 (compromise rating)

ATEC hardware and software require minor modifications.

28/ 29. <u>Receiver Deviation Test (A&B)</u>

<u>Usefulness</u>

PA-TA-1
Test is redundant with Receiver Pilot.

FI-2
This is a test of deviation obtained from the IF through a separate demodulator. Its potential usefulness is in isolating apparent deviation problems to the demodulator or pilot sensing circuitry.

<u>Availability -1</u>

Internal to subsystem control unit.

<u>Processing -4</u>

Can be processed by existing ATEC hardware and software.

30. <u>Receiver Baseband Waveform Comparison</u>

<u>Usefulness</u>

PA/TA-2
Tracking this difference over time might provide insight into gradual deterioration of one diversity path with respect to another.

FI-2
System distortion appearing in only one receiver chain may be isolatable by this approach.

<u>Availability -4</u>

Unused baseband outputs exist on the radio sets.

<u>Processing -1</u>

A hardware adaptation is necessary, and probably computer processing for interpretation and verification.

31/ 32. <u>Transmitter Power (A&B)</u>

<u>Usefulness</u>

PA/TA-3
Important for isolating the transmitter effect in analyzing RSL statistically, and for trending the transmitter itself.

FI-3
Useful for isolating sources of degradation insufficiently severe to cause the related alarm to trip.

Availability -3

Internal connection (raw) - P108

Processing -4

Can be processed by existing ATEC system elements.

33/ 34. Transmitter Frequency (A&B)

Usefulness

PA/TA-1
A secondary performance parameter. Eye pattern degradation monitoring provides more accurate evaluation.

FI-3
In conjunction with the conjugate receiver frequency value, can be used to silate sources of degradation due to off-frequency conditions.

Availability -3

At internal connectors, P108 and P107.

Processing -4

Can be processed by existing ATEC hardware and software.

35/ 36. Transmitter Deviation Test (A&B)

Usefulness

PA/TA-1
Checks only a limited part of the transmitter circuitry.

FI-3
Can be utilized to isolate deviation aberrations to transmitter or receiver.

Availability -1

Within subsystem control unit only. Requires control capability.

Processing -4

Can be processed by existing ATEC hardware and software.

37/ 38. Noise Bursts

Usefulness

PA/TA-2
Possible use, if trended, in detection of intermittent connections and transient events.

FI-4
Useful for isolating possible cause of otherwise inexplicable transient events in the digital system.

Availability (ranges from 1 to 4)

Can possibly be incorporated into eye pattern monitor (Availability 1, but required for other uses). Can also be developed separately, in which case more accessible points may be used.

Processing -1

Hardware development required. Software required for correlation of system-wide transient events.

MISSION
of
Rome Air Development Center

RADC plans and conducts research, exploratory and advanced development programs in command, control, and communications (C^3) activities, and in the C^3 areas of information sciences and intelligence. The principal technical mission areas are communications, electromagnetic guidance and control, surveillance of ground and aerospace objects, intelligence data collection and handling, information system technology, ionospheric propagation, solid state sciences, microwave physics and electronic reliability, maintainability and compatibility.